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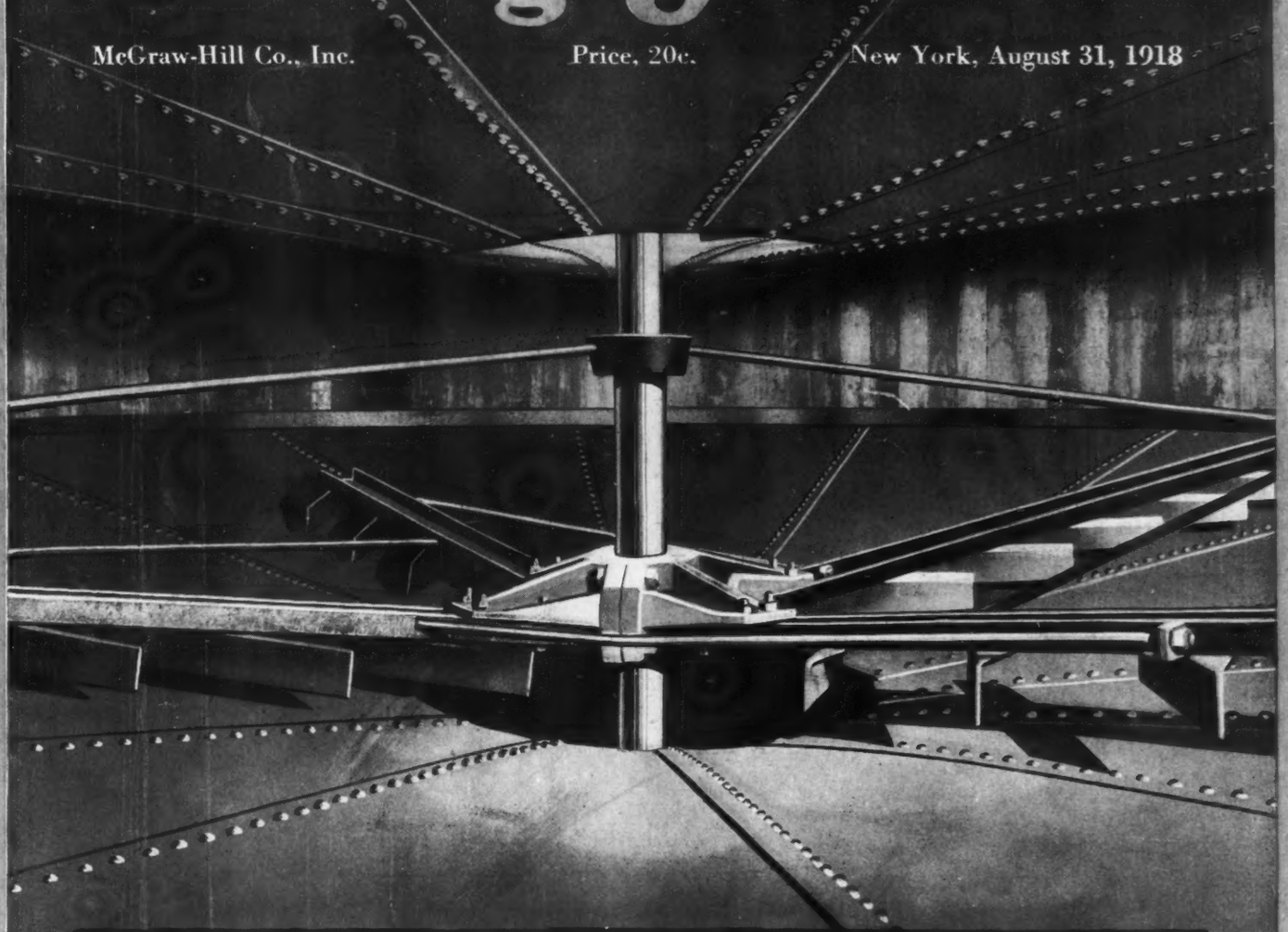
Engineering and Mining Journal

McGraw-Hill Co., Inc. Price, 20c. New York, August 31, 1918



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See page 18 of this issue for important data regarding performance of Dorr Bowl Classifiers.

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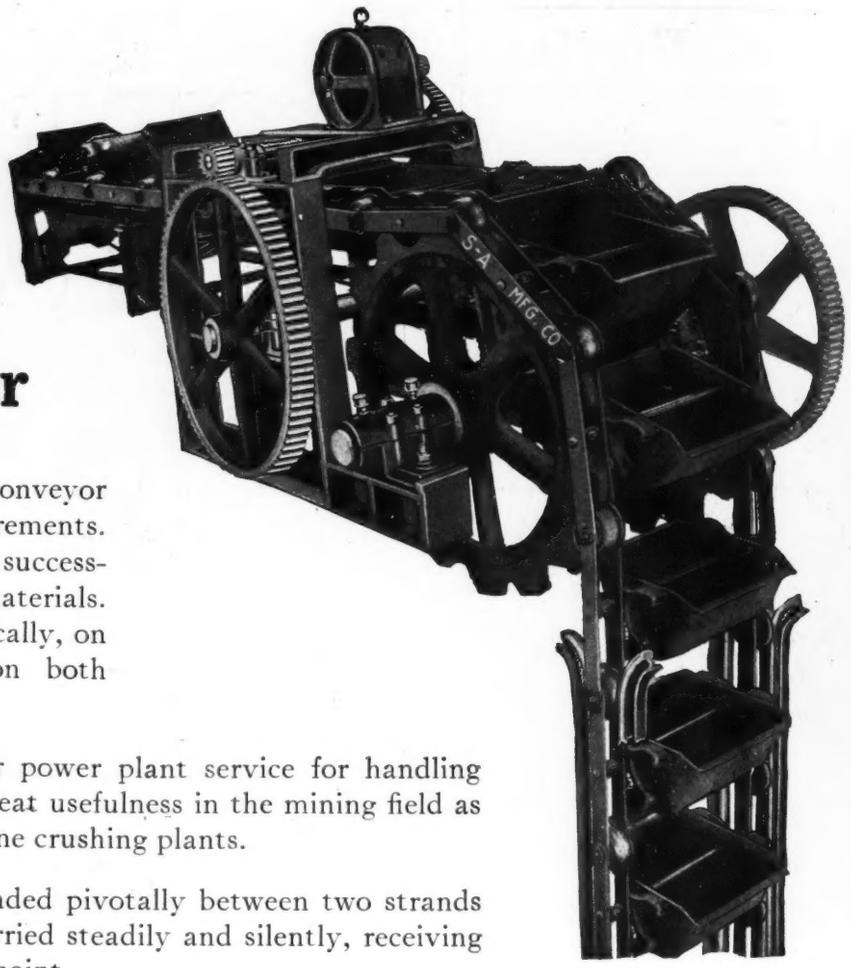

This is the "many-in-one" conveyor that is adapted to extreme requirements. It is the only conveyor that can successfully handle hot and gritty materials. More than that, it conveys vertically, on an incline, and horizontally on both upper and lower runs.

This conveyor is standard for power plant service for handling both coal and ashes. It has a great usefulness in the mining field as well as in chemical works and stone crushing plants.

Malleable iron buckets, suspended pivotally between two strands of long pitch roller chain, are carried steadily and silently, receiving and depositing their load at any point.

Difficulties have been overcome to the degree that means uninterrupted service with minimum expense and attention. This is the result of special features about which we will be glad to give you full information without obligation. Simply ask us.

"S-A" Unit Carrier

From the Single Unit Type to as many as conditions may require is the scope of these power, lubrication and belt savers. To prove to you that these carriers save the maximum and represent the utmost in carrier efficiency we will send one for a six-months' tryout. Where shall we send it?

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Engineering and Mining Journal

August 31, 1918

Volume 106 *Number* 9

RECEPTION ROOM, AMERICAN INSTITUTE OF MINING ENGINEERS, ENGINEERING SOCIETIES' BUILDING

American Institute of Mining Engineers And the War

By BRADLEY STOUGHTON

OF THE seven thousand present members of the Institute, 612 are known to be in the army of the United States or its Allies, 24 are in the navy, 59 in the air service, two are enrolled in the Red Cross, and 101 are engaged in other branches of Government work. Already, 13 are known to have died in service, making a total of 811 of which the Institute has definite records at this time. These records are doubtless incomplete, as there are many members whose addresses are lacking and who have given instructions to hold all mail and publications, presumably because they have left for the front.

It is proper that record should be made here of the names of those who have made the supreme sacrifice, notwithstanding that we know the list to be still incomplete.

At the Colorado meeting, memorial services will be held, at which the professional and military records of each of these men will be presented so far as they can be obtained. Later, this information will be published in the A. I. M. E. *Bulletin*, together with photographs.

In all justice to the patriotism of many scores of other members between the ages of 18 and 45, it should be recorded that, at the sacrifice of personal desire, they are continuing their engineering work in providing munitions and resources for carrying on the war, through the conviction that in this way they are rendering their most valuable, if not the most spectacular, service to the cause for which others are risking their lives. Finally, there are many members of the Institute who are giving a share of their time to professional work, without remuneration, at the request of the Government. These services include examinations of ore deposits or districts in which the Government is interested; professional visits, some of them outside of the country, searching for "war minerals" of which there is a scarcity; researches on the properties of metals and processes of production; and part-time occupation as consulting engineers or metallurgists to the Ordnance, Navy, and other Government departments.

Probably no group of men is more actively engaged in professional life than are mining engineers and metallurgists in producing materials necessary for carrying on the war, including steel, of which cannon, rifles, projectiles, ships, and machinery are made; copper for electric conductors, projectile bands and so forth; zinc for

cartridge brass; lead for bullets, etc.; platinum, mercury and other metals necessary for, or accessory to, the manufacture of arms and explosives. Then there are many minerals essential for the manufacture of war materials, of which a scarcity has been brought about by the difficulties of ocean transportation. Members of the Institute have responded most generously in assisting in the discovery and stimulating the production of these minerals at home; some by giving up their professional work entirely and going into the Government service, and others by professional work, reconnaissance, mine examinations, and like activities. The net result has been the addition to the resources of our own country of valuable, and in some cases enormous, deposits of sulphur, and of chromite, manganese, and other steel-alloying elements.

In its official capacity the Institute has assisted in the recruiting of the 11th Railway Engineers; in active participation in the work of the Naval Consulting Board, and the War Committee of Technical Societies; in the financial and other support of the National Research Council and of the War Minerals Committee. It rendered active service in stimulating the production of manganese and pyrite, and has been effective in supplying a great many engineers for Government work through a central body maintained for the purpose of acting as a medium in this respect between all Government departments and the technical societies.

At the request of several departments of the Government, the Institute is furnishing them free copies of its *Bulletin*, and at the request of the American Library Association it is sending its *Bulletin* to a great many of the military cantonments, especially where engineers are being trained. Lack of space forbids recording the many services, official and semi-official, that are being rendered, but mention should be made here of the generosity of Dr. Gardner F. Williams, who has donated a great many copies of his book "The Diamond Mines of South Africa," which is advertised and sold by the Institute, the entire proceeds

DIED IN SERVICE

LEWIS NEWTON BAILEY
Died of pneumonia, Apr. 30, 1918.

LOUIS BAIRD
Died on battlefield in 1915.

WILLIAM MORLEY COBELDICK
Died from gas poisoning, Oct. 7, 1915.

RALPH DOUGALL
Killed in action.

ALFRED WINTER EVANS
Killed in action, Oct. 12, 1917.

WILLIAM HAGUE
Died in active service, Jan. 1, 1918.

WILLIAM T. HALL
Killed in action in France, May 19, 1917.

JOHN D. IRVING
Died in active service in France, July 26, 1918.

EDWARD H. PERRY
Killed in action, Mar. 30, 1918.

FRANK REMINGTON PRETYMAN
Killed in action, June 17, 1916.

FRED B. REECE
Killed in action.

SOREN RINGLUND
Died July 24, 1918.

GEORGE ROPER, JR.
Killed in aëro accident in England, May 25, 1918.

being turned over to the American Red Cross. Several hundred dollars has been contributed in this way, neither Dr. Williams nor the Institute receiving any share of the proceeds, nor any return of the expense of sale and distribution.

The A. I. M. E. in Colorado

There are 243 members of the Institute in Colorado. Of these, 114 reside in Denver, making that city one of the large and representative centers of the society. The intensive mineral development in the state and the successful exploitation of many mines in widely separated localities have made Colorado an attractive field for mining engineers and metallurgists.

From a technical standpoint Colorado engineers must be credited with many notable contributions to the advancement of the industry. Among the more important are development of sampling companies and principles of ore sampling; concentrating, sampling, cyanide and chlorination mill design, construction and operation; treatment of the telluride gold ores of Cripple Creek; development of silver-lead smelting, and gold and silver refinery practice; Bartlett process for the treatment of lead-zinc sulphide ores; chemical treatment of uranium, vanadium and tungsten ores; production of ferroalloys; design of bag-houses, dust-filtration, and smelting-works flue systems; construction of improved crushing rolls, concentrating tables, ball mills, and other ore-dressing appliances; design and construction of silver-lead and pyritic blast furnaces; application of wire-rope tramways to a difficult topography and their extensive use for mining transportation; use of long mine adits for development and drainage purposes, and the development of methods for their construction; invention and introduction of the Waugh stoping drill, the water Leyner drill, and the Leyner air compressor.

The most noteworthy plant in the state is that of the Colorado Fuel and Iron Co. at Pueblo. Despite many difficulties, this company has established an important iron- and steel-making industry. Steel and iron are not only turned out in pig and billet form, but as wire, nails, spikes, bolts, nuts, reinforcing bars, blacksmith iron, wire fencing, steel rails and structural steel, and cast-iron pipe.

The more important Colorado corporations include the Portland Gold Mining Co., which paid dividends until the beginning of 1918 amounting to $10,957,080. The Victor Mill, at Victor, is a notable installation in many respects; and the Independence mill, in the same locality, which is of more recent design and construction. The Victor and Independence mills have a combined rated capacity of 60,000 tons monthly. The Golden Cycle plant, at Colorado Springs, is a special installation designed for handling high-grade ores of an uncommon type. The American Smelting and Refining Co. operates important plants at Denver, Pueblo, Durango and Leadville; and the Ohio & Colorado Smelting and Refining Co. has a large custom smeltery at Salida.

Among the important mining-machinery firms in the state are the Colorado Iron Works Co., the Denver Engineering Works Co., the Hendrie & Bolthoff Manufacturing and Supply Co., the Mine & Smelter Supply Co., the Dorr Co., the Stearn-Roger Manufacturing Co., the Morse Bros. Machinery and Supply Co., and the Denver Fire Clay Co. The Colorado Iron Works Co. did pioneer work in the development of silver-lead and pyritic blast furnaces. Its special equipment enables it to carry on an extensive business in smelting appliances and ore-dressing equipment. Important though unsuccessful efforts were at one time made to develop an oil-burning blast furnace. The Denver Engineering Works Co. has made important modifications in crushing-roll design, and introduced the Richards pulsating jigs and classifiers. The recent absorption by Hardinge interests promises to result in a strong combination that will specialize in mill design and the manufacture of ore-dressing appliances. Few Western mining men are unacquainted with the Hendrie and Bolthoff Manufacturing and Supply Co. and the Mine and Smelter Supply Co. Both of these companies carry varied stocks of mining machinery supplies; they are the selling agents for manufacturers of compressors, rock drills and miscellaneous mine and mill equipment, and have shown great enterprise in introducing concentrating tables and milling appliances. The Dorr Co., manufacturers of the well-known classifier, thickener, and other hydro-metallurgical appliances, has its laboratories and principal offices in Denver. The Stearns-Roger Manufacturing Co., deals in mill and factory supplies; the Edwards roasting furnace and the Wetherill magnetic separator were introduced by this firm. The Denver Fire Clay Co. is a well-known manufacturer of oil-burning muffle furnaces, crucibles, fire brick, and fine balances, as well as an important supply house for chemicals and chemical apparatus.

The Ainsworth assay balance, put upon the market by Wm. Ainsworth & Sons, marked a beginning in the construction of precision balances. There is scarcely a Western assayer who is not familiar with this balance. Smith and Thompson, employed by Ainsworth, opened a factory of their own, and thus Denver became the center for the manufacture of fine balances. The Denver Rock Drill Co. has been successful in creating a market for the Waugh drill and is now one of the leading manufacturers of rock drills.

J. George Leyner established at Littleton a machine shop and began the construction of mining machinery. The "water Leyner" drill made use of the "hammer principle," hollow steel and a water jet discharged at the drill bit. It was eminently successful and speedily established itself in the esteem of mining men. The Leyner air compressor was an excellent machine and was introduced into a number of Colorado mines. The Leyner drill sharpener was another successful appliance. The J. George Leyner Co. was absorbed by the Ingersoll-Rand Co., and its products are now sold by the latter named company.

Part of the membership of the A. I. M. E. is scattered among the above-named companies and many are in others in the state—as superintendents, managers, mining engineers, metallurgists, assayers, surveyors and chemists and in other technical capacities. The local section of the A. I. M. E., under the leadership of Charles M. MacNeill, chairman, George M. Taylor, vice chairman, Fred Carroll, Secretary, W. W. Case and H. E. Collbran, has held many interesting meetings. It is doing effective work, as may be judged by the number, variety and importance of the papers presented at the Colorado session by Colorado members.

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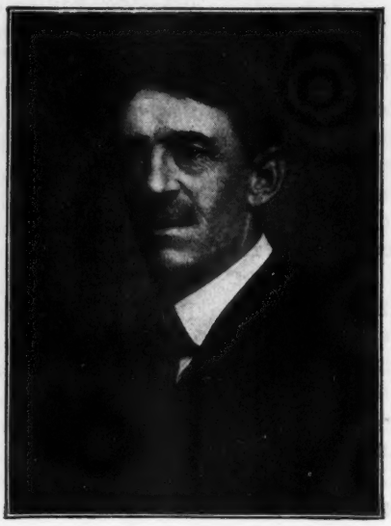

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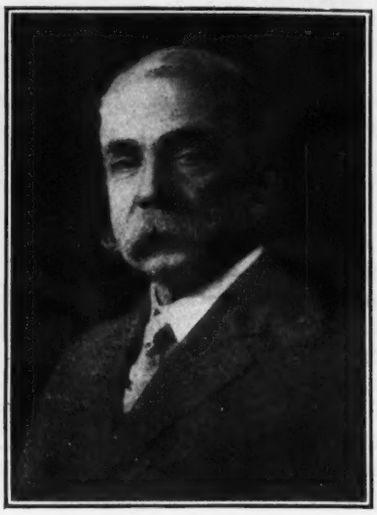

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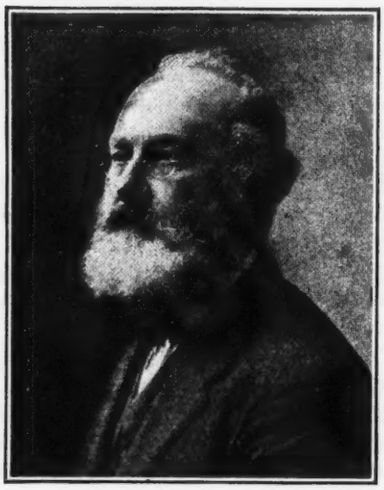

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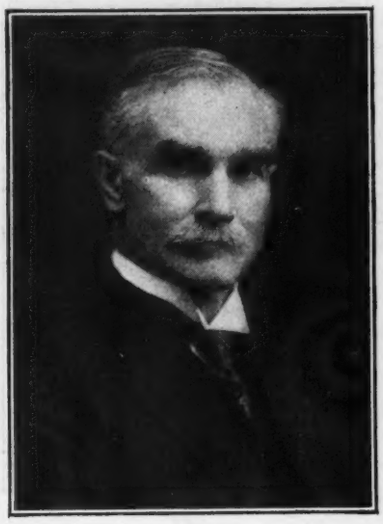

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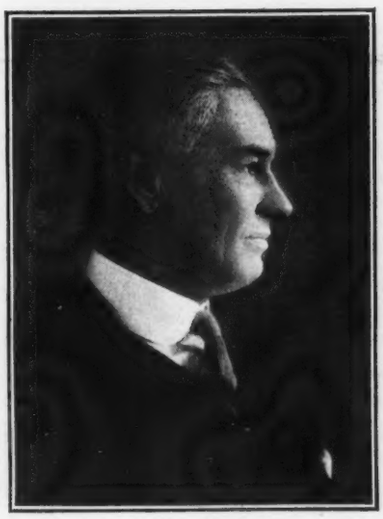

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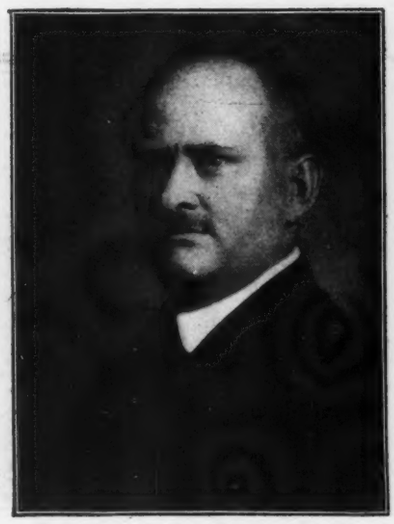

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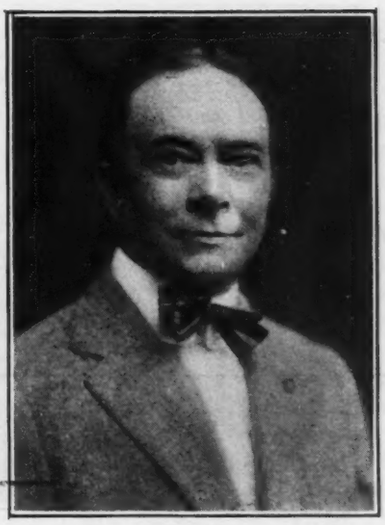

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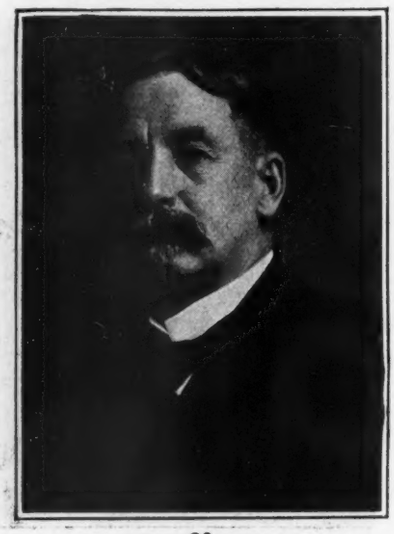

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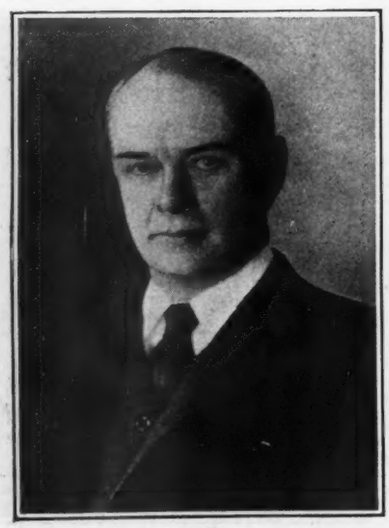

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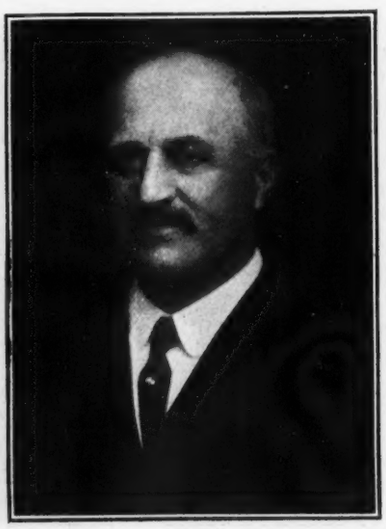

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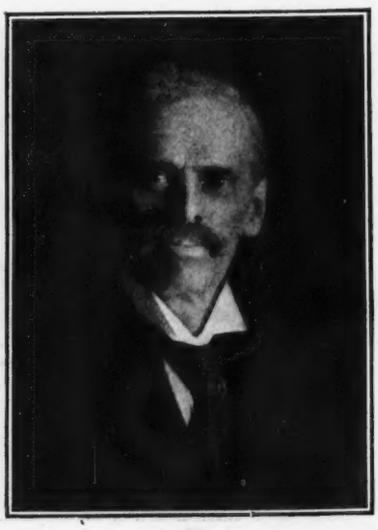

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Colorado Mining in 1918

Colorado mines are now passing through a period of adjustment, the final results of which will not be apparent for two or three months. For many operators the situation is critical, and others are apprehensive of the future, for the prices of labor and material are mounting, and the margin of profit of some mines has for many years been slight. Many small properties have closed; others have continued with diminished forces. The shipments in May and June, which should have been greater than those of the winter months, were materially less.

According to Charles W. Henderson, of the U. S. Geological Survey, the production for the first six months of 1918 shows a considerable decrease for gold and an appreciable decrease for silver. Copper has never been an important mineral in Colorado, and in 1918 so far it shows an appreciable decrease as compared with 1916 and 1917. The output of lead has remained practically stationary during 1918. The market for the low-grade zinc ores of Colorado is not encouraging, and the production has already fallen off considerably. There are no truly high-grade zinc ores in Colorado comparable to those of the Miami, Okla., field.

The production of gold from Cripple Creek for the first six months of 1918, as compared with the same period in 1917, shows a decrease of approximately $800,000, which, if continued, means, for the year a decrease of $1,600,000 to $2,000,000. The Golden Cycle cyanidation mill at Colorado Springs has been operated steadily in 1918, but the Colorado Springs mill of the Portland Co. was closed in April. The company has offset in part the loss occasioned by this closing by sending the ore from its mines to its 1000-ton Independence mill at Victor, where the Portland and Victor 500-ton mill for low-grade ores is also situated. The small cyanidation mills in the Cripple Creek district have been idle.

Leadville already shows a decrease in the output of gold, silver, copper and zinc, but an appreciable increase in the output of lead. The output of manganese iron ores from Leadville for use at steel plants has been steady. The reopening of the Ute and Ulay mines at Lake City, Hinsdale County, and the development work at Creede promise to add to the lead output of Colorado. San Juan County has not quite maintained the output it made in 1917, but the San Miguel County (Telluride) mills have produced at a greater rate. The development adit of the Camp Bird mine has reached the vein, but the rest of the year will be spent on development work, so that probably no production can be counted on from that mine, which, up to 1916, was a large contributor to the output of gold, as well as lead, silver, and copper.

Decreased supplies of ore have caused the closing of the sampling works at Black Hawk, Gilpin County, and at Georgetown, Clear Creek County, both old establishments. The sampling works at Idaho Springs has continued its operations. The number of active mines in Boulder County has become small. The dredges in Summit County have so far not yielded their usual output, but the production during the first three months of the year is generally low at Breckenridge; the dredging begins to be productive in June. The sampling works at Breckenridge has been closed. The Derry Ranch dredge, near Malta, Lake County, resumed operations in May. Mines at Bonanza, Saguache County, have continued in operation, with promise of a considerably increased production when the Rawley Co. completes its tramway from Bonanza to its mill now building at Shirley.

ROSSITER W. RAYMOND,
Secretary Emeritus

BRADLEY STOUGHTON,
Secretary

THE SECRETARIES OF THE AMERICAN INSTITUTE OF MINING ENGINEERS

Remember the Comfort Fund of the 27th Engineers.

War Minerals of Colorado

Lead, Zinc, Gold, Silver, Tungsten and Copper Ores—Uranium, Vanadium and Radium Produced From Carnotite, Vanadinite and Pitchblende Ores

BY A. H. HUBBELL

NO STATE in the Union is better able than Colorado to respond to the urgent demand for war minerals. Abundantly endowed with deposits of gold, silver, lead and zinc, it is also the foremost producer of tungsten, vanadium, uranium and radium. Of less importance as a source of copper than other parts of the West, its output of that metal in 1917 nevertheless secured for it the eleventh place in the list of states. Colorado, moreover, was one of the seven states producing the bulk of manganese ore mined in the country last year. Molybdenum, fluorspar, iron and other minerals in lesser quantities are among those contributing to the wealth of the American Switzerland. It therefore remains for the powers that be, in Washington and elsewhere, to see to it that the maximum good shall accrue to the American people as a whole, as well as to the citizens of Colorado, through the proper exploitation of this treasure house. At a time when the economic strength of the nation is being carefully measured by extensive surveys, and the need of proper distribution of raw materials is becoming of great importance, anything tending to cripple a vital industry, such as gold mining, for example, should be remedied without delay.

Earlier in the war, the high prices paid for base metals, as well as the prevailing high costs, caused greater attention to be given in Colorado to producing these metals than was devoted to gold and silver. However, the improved silver situation, culminating in the signing of the Silver bill on Apr. 23 by the President, and, on the other hand, the alarming conditions facing the gold-mine operators, have again thrown the precious metals into the limelight.

DECLINING GOLD OUTPUT

The output of gold in Colorado in 1917 was 15% less than the year before, declining from 19,009,100 oz. in 1916 to 15,955,100 oz. in 1917. Even at that, the 1917 production was almost a fifth of that of the entire country, and put the state in second place, following California. The general occurrence of gold as well as silver in Colorado's ores is reflected in the fact that an average analysis of the ores smelted at the five big lead-silver plants of the state, situated at Denver, Pueblo, Leadville, Durango and Salida, during the five-year period from 1912 to 1916, showed an average content of over ½ oz. of gold and 12 oz. of silver per ton. The labor shortage, general throughout the state, affected the gold-mine operators more seriously than others, because of their inability to bid as liberally in securing men, by reason of the standard value of their output. Many mines have been forced to shut down owing to this fact and to other causes.

Silver mines, on the other hand, fared better, and many properties have been reopened. Of the total 1917 silver output of the United States, 74,244,500 oz., Colorado produced 8,163,600 oz., ranking as sixth highest.

Lead in Colorado is derived almost entirely from lead-silver ores. The five smelteries already mentioned, four of which belong to the American Smelting and Refining Co., the remaining one being the plant of the Ohio & Colorado Smelting Co. at Salida, have, in all, 32 furnaces, with a combined capacity of 1,955,000 tons of charge per year. Strange though it may seem, it is necessary to import rich lead ores into the state to bring the average tenor of the furnace charge up to 10% lead (or, better, 12%). Colorado ores smelted during the five-year period from 1912 to 1916 carried only 6.76% wet lead, which is insufficient to smelt them. The additional lead necessary for the reduction process must be shipped, refined and marketed. This condition entails a heavy extra charge on the production of lead from Colorado ores. In testifying before the Smelter and Ore Sales Investigation Committee of the State of Colorado, the general manager of the Ohio & Colorado company's plant stated that about 70% of the total lead smelted at Salida came from ores produced outside of the state, which were laid down at heavy loss at Salida in order to make operations possible there. The mining of lead-silver ores has, of course, been greatly stimulated by the better prices obtained for the product.

COPPER

Though the production of copper in Colorado is overshadowed by that of the other major metals, the 12,028,000 lb. derived from ores of the state last year secured to it the position of eleventh in rank. Copper ore is mined in various parts of the state, including the Anaconda property, at Iola, and the Akron at White Pine. Ironton and Red Mountain ore is shipped via Silverton. Other plants produce copper concentrates, but the greater part of the metal is derived indirectly from the lead-silver ore. Such ores as were smelted at the five lead-silver plants from 1912 to 1916 contained 0.61% copper on an average. The state boasts only one copper smeltery, that of the Wanakah Mining Co., at Ouray, which has two blast furnaces, with an annual capacity of 105,000 tons of charge, not including fuel.

TUNGSTEN ORES

It is in tungsten that Colorado shines most brightly as a producer of war minerals. Its output of tungsten minerals is about equal to that of California, the two states producing well over 80% of the total quantity mined in the United States, which is estimated for last year at somewhat less than 5000 tons of products equivalent, on an average, to 60% WO_3 concentrates. Before the war, the entire country failed to produce enough tungsten to meet the domestic demand, which has now become three times as great as before. The importance of this industry in Colorado can therefore hardly be overestimated. Moreover, the tungsten produced in the state, being free from tin, is superior to the imported.

The deposits of tungsten in Colorado, as elsewhere in the United States, are extremely small. There are no large bodies of 1% ore in the state. Ninety per cent. of the output comes from ferberite deposits in Boulder County and the northern part of Gilpin County. The producing district lies about 25 miles northwest of Denver and is about 12 miles long by 7 miles wide, the principal centers being Nederland, Lakewood and Stevens Camp. The deposits are worked largely by lessees, and the ore is hauled for treatment to centrally situated mills, about 10 of which are in the district.

The oldest and largest tungsten company in the district in Boulder County is the Primos Chemical Co. Other operators are the Wolf Tongue Mining and Milling Co., the Vasco Mining Co., the two together operating about 24 mines; the Boulder Tungsten Production Co., and the Tungsten Metals Corporation, as well as several other producing companies. Some of these companies are making tungstic acid or ferrotungsten, or both, on the spot. In particular, the Tungsten Products Co. and the Black Metal Reduction Co. are making tungstic acid, the latter company also making ferrotungsten in an electric furnace. The Rare Metals Ore Co. is operating at Rollinsville, Gilpin County. Elsewhere in the state, hübnerite is mined in San Juan County near Silverton; hübnerite and scheelite both are produced at Leadville in the Garbutt and Ibex properties; and hübnerite occurs at Alma, in Park County. Other discoveries have been made in Eagle and Chaffee counties.

Remarkable advance has been made in the dressing of tungsten ores, particularly in Boulder County, where the milling of ores without metallic impurities is said to have reached the highest stage of development attained anywhere.

Western Tungsten Producers and the Tariff Commission

On June 28, Western tungsten producers appeared before Commissioner William S. Culbertson, of the U. S. Tariff Commission, and Guy C. Riddell, metallurgical expert of the commission, at a hearing in San Francisco, following one held at Denver on June 17. In the course of the testimony, it was brought out that the cost of producing tungsten ores in Colorado ranged from $15 to $33 per unit, compared with much lower costs in California. The witness said, however, that such costs were extremely difficult to determine, as the deposits were uncertain and the reserves limited. Another witness said that the life of tungsten properties was so short that depreciation was figured at 50%, though there was no set rule. Among the difficulties said to be confronting the small tungsten producer were mentioned the following: Abnormally high operating costs; fluctuations in the ore market; inability of small producers to ship in car lots; lack of stabilized price for local ores; and last, but not least, the middleman.

Production of Ferrotungsten

It is interesting to note that a center in which final products such as tungstic acid and ferrotungsten are being made is growing up in the vicinity of Denver. New companies have also entered this field. A new 200-kw. furnace for making ferrotungsten has recently been established near Denver. Metallic tungsten is obtained from its ores only as a black powder, which is sold to steel makers, and contains usually about 98% W, 0.5% Fe, 0.5% Si, 0.1 to 0.2% C, and practically no sulphur or phosphorus. Ferrotungsten, the alloy of iron and tungsten, as produced in the electric furnace, contains from 50 to 85% W and 0.5 to 4% C.

Tungsten producers have had the same troubles as to labor scarcity and rising costs that have confronted those in other industries. The opinion has been expressed, however, that in Colorado output can be doubled if an adequate and stable price for ores and products be established by the Government and if protection be given from cheaply produced imports.

Vanadium and Uranium and Radium

The vanadium, uranium and radium industries are closely linked, and equally intimate is their association with the name of Colorado. The main source of the three important elements is the carnotite ores of the state, though the Primos Chemical Co. is also producing vanadium from Colorado roscoelite ore. Colorado's output of vanadium ores, however large compared with that of other states, is a small per cent. of the amount of Peruvian patronite ore imported, which is the origin of most of the vanadium used in this country.

The chief producers of vanadium and uranium, with the latter of which radium is associated, are the Primos Chemical Co. and the Standard Chemical Co. Practically all the uranium entering into steel manufacture now comes from Colorado, being derived, along with vanadium, from carnotite, though there is a deposit of pitchblende in Gilpin County that has so far yielded a small part of the output. Engaged in the production of radium are the National Radium Institute, the Pittsburgh Radium Co., the Standard Chemical Co., the Schlesinger Radium Co. and the Chemical Products Co. Radium was formerly in demand for experimental and medicinal purposes, but a new use for it has sprung up in the manufacture of luminous paint, to which the war has added impetus. Such paint is employed on watch dials, compass faces, gun sights and for like uses, to make the objects treated visible at night. However important and valuable these elements are, they are produced in comparatively small amounts, that of radium, of course, being minute.

Manganese Ore Production

Colorado ranked seventh in 1917 among the seven states producing the bulk of that year's domestic output of manganese ore, the demand for which has been so greatly increased through the cutting off of Brazilian imports, owing to the scarcity of ocean tonnage. Much of the state's output comes from the manganese-silver ores of the Leadville district. Metallurgical or 40% manganese ore is rare in Leadville, though 30% ore exists in large quantities. The U. S. Geological Survey has recently estimated that 13 deposits in the district named contain about 700,000 tons and possibly 1,500,000 tons of ore averaging 20 to 25% Mn, 24 to 30% Fe, and 10 to 15% SiO_2. Similarly at Red Cliff, Colo., two deposits are estimated to have probably 750,000 tons and possibly 1,000,000 tons of ore analyzing 14% Mn, 38% Fe and 1 to 2% SiO_2, all these ores being low in phosphorus.

Tests are being made at the Golden station of the U. S. Bureau of Mines on manganese-silver ores with

the Caron process, which recovers the silver by leaching and precipitation and the manganese as a byproduct. This work is under the supervision of George H. Clevenger, and is being done for the Bureau of Mines, the Netherlands government and the Research Corporation of New York. The Golden station was selected because of the large bodies of the manganese-silver ores occurring in Colorado.

In a list of shippers of manganese ores recently published in the *Journal*, the only one named in Colorado outside of the Leadville district was J. D. Batie, of Pueblo, though Boyer and Frankenberry, of Salida, and the Colorado Manganese Mining and Smelting Co., of Denver, were named as prospective shippers.

Molybdenum and Fluorspar

Molybdenum and fluorspar also occur in Colorado, but at present assume less important parts in the mining industry of the state. The Primos Chemical Co. has developed an extensive molybdenite property in Clear Creek County, near Empire, and also has established two plants for treating large deposits of disseminated molybdenite at Climax, north of Leadville. The Climax company, according to H. L. Brown and M. W. Hayward in the *Journal* of May 18, 1918, has developed over 6,000,000 tons of 1% MoS ore, and it is estimated that double this tonnage exists. This ore contains no obnoxious ingredients and no other mineral except a little pyrite. As stated before, it is fine grained instead of coarse and flaky.

Fluorspar was regularly shipped during 1917 from Wagon Wheel Gap, near Creede, and from the Barstow mine, near Ouray, as well as from the vicinity of Jamestown, in Boulder County. No tonnage figures are at present available, but undoubtedly they would be small. The total production in the United States in 1916 was only approximately 155,000 tons, about three states producing, including Colorado.

As for potash, it is said that the phonolite ores of the Portland, Vindicator, Golden Cycle and other mines of Cripple Creek contain 6% of recoverable potash. It is similarly stated that the dumps of the two mills at Colorado Springs contain 6,000,000 tons running 6 to 10% in potash. The establishment of a plant to work these dumps and to handle current tails is talked of. However, until the potash industry has secured a firmer footing in this country, even on a war basis, it is unsafe to commit one's self to predictions as to its future.

Pyrite Deposits of Leadville, Colorado*

By Howard S. Lee†

The ore-bearing formation of the Leadville district consists of two beds of limestone separated by a layer of quartzite. The upper carbonaceous limestone, known locally as the blue limestone, varies in thickness from 50 to 300 ft. The lower or Silurian limestone is about the same thickness as the upper bed. Underlying the Silurian limestone is a layer of Cambrian quartzite from 100 to 250 ft. thick resting on Archean granite, which forms the limit of ore deposition. Usually, there is a sheet of white porphyry above the upper limestone; a sheet of gray porphyry is associated with the blue limestone, either in or below it, but the porphyries are not as regular as the quartzites and limestones and are not always found in expected positions.

An elaborate system of faults and intrusive porphyry dikes has an important bearing on ore deposits throughout the district, and it may be said that most orebodies are directly traceable to one or both of these causes.

The distribution of pyrite in the Leadville district is general. The chief pyritic orebodies extend in a zone approximately 6000 ft. long and several hundred feet wide, from the Yak and Moyer, on the south; through the Louisville, Greenback, Mahala, Adams, and Wolftone mines, on Carbonate Hill; across Yankee Hill, and into the Quadrilateral, Denver City, and Tip Top, on Fryer Hill.

The orebodies occur as replacement deposits in the limestone along a minor fracture, or contact metamorphic deposits along a porphyry dike or fault. Replacement deposits closely related to intrusive gray porphyry dikes are the most important and most prevalent. Deposits of manganiferous siderite which inclose iron orebodies, particularly in the carbonaceous limestone, are closely associated with iron sulphide orebodies and often indicate the presence of ore when approached from the outside, and mark the limits of ore when approached from the inside. The fact that the pyrite is surrounded by siderite would indicate that the pyrite had been deposited first.

After the pyrite was deposited, there were at least two periods of further action in which other minerals were introduced. Two periods are apparent at the Yak mine, where pyrite was deposited along a fracture system having a general northeast direction. At a later period, there was movement resulting in fracturing along a N 15° W course, and it is along these fractures that secondary zinc enrichment is encountered. Still later there was movement along the original northeast system where secondary silver enrichment took place. At the Denver City mine, only secondary enrichment of silver has occurred, and the ore contains no zinc or lead. The enrichment here is similar to conditions at the Louisville mine, in that lines of weakness developed along small dikes of porphyry. The mechanical action in both cases would be the same, the only difference being that the precipitating action of the porphyry and pyrite together would be greater, and higher assay values would be found along the small dikes.

The ore is a compact, fine-grained, fairly hard pyrite. Along enrichment zones, the ore is fractured and granular, whereas the barren pyrite is much harder. This would naturally form ribs of harder material between oreshoots, which in many cases have been left in lieu of timbers.

The method of mining has consisted of driving exploratory drifts to determine the zones of enrichment and the walls, and, when the preliminary information was obtained, using the ordinary square-set method with selective mining. If it was found too expensive to hold the more or less barren pyrite in place, it was taken out and sold to the smelters for what little gold or silver it might contain, as well as for the iron. In two or three cases, notably at the Yak and Leadville unit, it was found more profitable to mine the entire

*Abstract of a paper by Howard S. Lee to be read at the Colorado meeting of the A.I.M.E., September, 1918.

†Leadville, Colorado.

orebody, as the zones of enrichment were small but frequent, and the mass was heavy. In this way unit costs were reduced, the tonnage was increased, and the total profit was greater than if the richer parts had been gouged out and the larger part allowed to remain in place.

Because of the small amount of sulphuric acid manufactured and consumed in Colorado, and the high freight rates to the eastern part of the country, which precludes competition with Eastern and Spanish pyrites, little Leadville pyrite has been used in the manufacture of acid, although small shipments have been made. Occasional trial lots have been shipped East, which have roasted satisfactorily.

There are large deposits of pyrite in Leadville, containing a minimum of 43% sulphur, suitable for the manufacture of sulphuric acid. In these deposits, enrichment zones contain gold, silver and zinc, but the system of mining in use will permit selective methods whereby the part more valuable for other metals may be stoped separately and shipped to the smelteries, the pyrite being kept clean for acid use. The only material available now is run-of-mine ore suitable for crushing and roasting in "fines" burners. The problem of lump ore, both as to suitability and preparation, will be worked out only when there is sufficient demand to warrant experiments.

Development of the Coke Industry In Colorado, Utah, and New Mexico*

The history of Western coke has been closely related to the development of the metallurgy of iron and steel and the precious metals in Colorado. The first smeltery was established in 1877, at Malta, by A. R. Meyer, but it was not successful and was succeeded by the Harrison Reduction Works, in 1878. The La Plata began with one furnace in June, 1878, and in 1879 was operating four furnaces. These used charcoal for fuel, but, because of hot tops, suffered a tremendous loss in lead and silver, which was overcome by the erection of 50 single-bank 10-ft. bee-hive ovens at Crested Butte in 1880. The slack coal sent to these ovens was pure, and yielded a coke carrying as little as 4.5% ash.

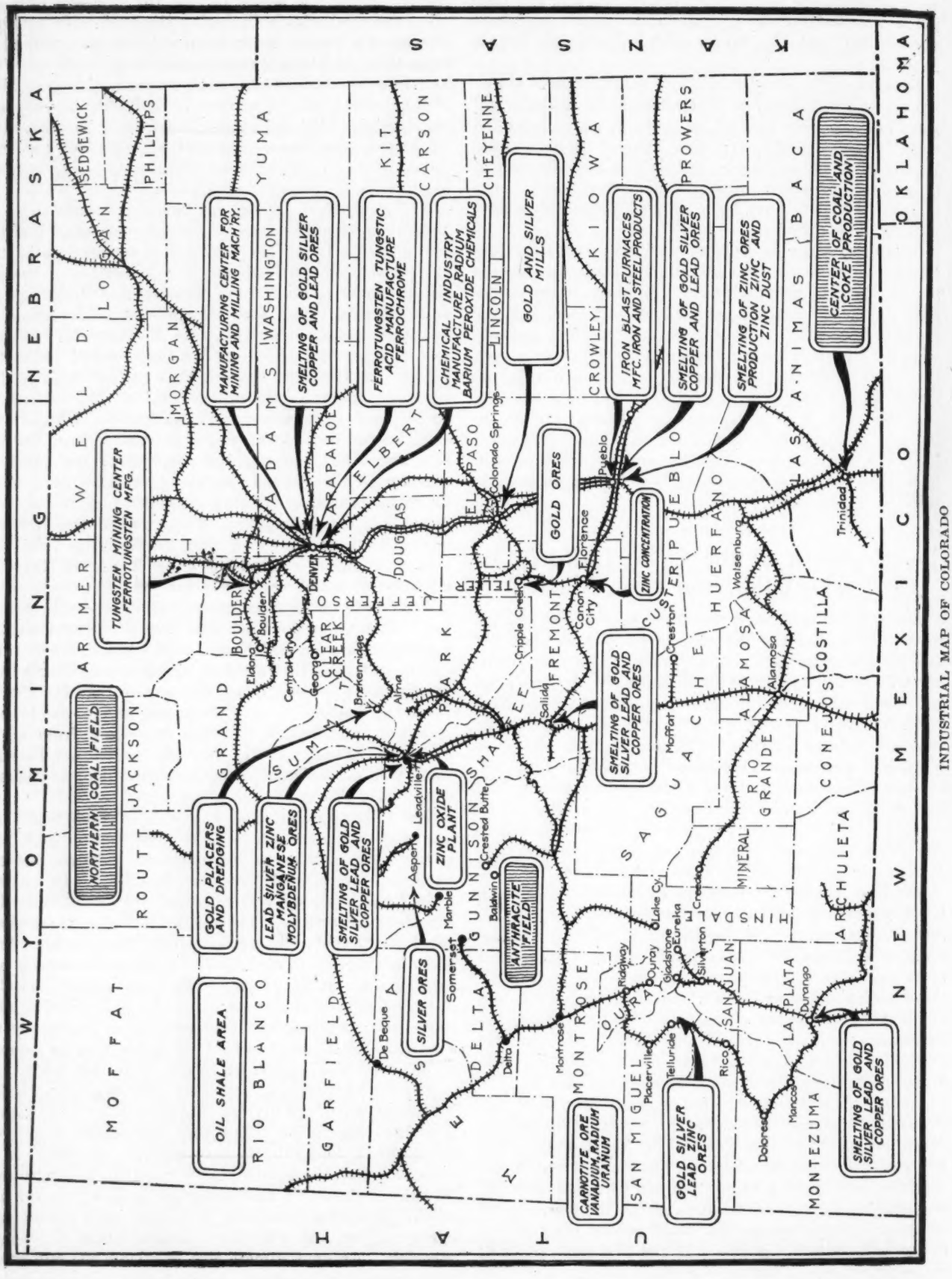
The first smeltery, erected in Pueblo by Mather and Geist, grew into the immense Pueblo Smelting and Refining Co., now a part of the American Smelting and Refining Co. Coke for these small furnaces was made from unwashed Engleville coal, in 186 single-bank 12-ft. ovens at El Moro, in the Trinidad district, and it was not uncommon for the percentage of ash to exceed the percentage of fixed carbon in the coke. On Jan. 23, 1880, the Colorado Improvement Co. consolidated with other companies to form the Colorado Coal and Iron Co. In 1881, this company erected a small iron and steel works at Bessemer, which has grown into the present Minnequa plant of the Colorado Fuel and Iron Co. The reorganization of the Colorado Coal and Iron Co. in August, 1896, to the present Colorado Fuel and Iron Co., resulted in active progress toward the improvement of its coke. Washeries at that time consisted chiefly in costly experiments. Sopris was the first coke plant to have a fairly efficient washery. In 1899, the Colorado Fuel and Iron Co. purchased the patent right to the Forrester plunger jig, which became the standard unit for all of the washeries built during the years 1900 to 1902. During this period, many standard batteries of double-bank 13-ft. ovens were constructed by the Colorado Fuel and Iron Co. and by coal companies operating in New Mexico and Utah. Previous to 1898, there were approximately 1600 coke ovens operating in Colorado, Utah, and New Mexico, without a single coal washery. At the end of 1902 there were 5900 coke ovens in operation, with 12 coal washeries.

The Utah Fuel Co. erected ovens at Castle Gate, in 1888, to handle Montana trade, but it was found that the coking property of the coal was deteriorating as the mine developed. An exhaustive examination of the entire property resulted in the discovery of a coking coal at Sunnyside which does not possess uniform coking qualities, and it is necessary to disintegrate the slack to a fineness of ⅛ in. before the best results can be obtained. In 1900, the Dawson Fuel Co., operated by the Phelps-Dodge interests at Dawson, N. M., erected 95 double-bank 13-ft. ovens and a washery, which gave inefficient results. After experimentation with various jigs and other coal-washing appliances, the company constructed an all-steel washery and assembled units of double-compartment jigs, concentrating tables, centrifugal driers, and appliances which make this washery second to none in the United States. In 1905, the Dawson company erected 480 under-flue ovens, the construction of which shows a great saving in boiler fuel, and the coke has a structure suitable for copper smelting. The Colorado Fuel and Iron Co. experimented with a stack oven which was of the bee-hive type, but the gases passed through flues under the floor and then up through a stack. The object was to coke the charge from the bottom up and from the top down in one operation, and reduce the time of coking from 48 to 24 hours. Finally the system was abandoned because there was not sufficient heat under the floor to make a dense coke.

The Colorado Fuel and Iron Co. in 1908 began an active development of oven construction. Coke machines were installed at Segundo and Tabasco, and experiments were made on oven building. Previously oven retaining walls had been built of stone, laid with a batter of 2 or 3 in. The results of experiments show conclusively that reinforced concrete walls, without batter, are superior to stone. The reinforced concrete retaining walls of the ovens of the Carbon and Coke Co., operated by the American Smelting and Refining Co., have been operating about 10 years with practically no repairs. The Covington coke extractor was introduced to offset the rapid decrease in available oven labor.

The H. Koppers Co., has erected at Minnequa, Colo., 120 ovens which are divided into two batteries and have a coking capacity of 46,000 tons per month, each oven being 40 ft. long, 10 ft. high and 19 in. wide. It is presumed that the coking period will be between 16 and 18 hours. Provision has been made at this time for use of the excess gas, recovery of ammonium sulphate, recovery of tar and oils, and a special plant for benzol recovery. An approximate cost of $5,000,000 will cover the ovens, coal washery, benzol plant, coke-screening plant and various appliances.

*Abstract of a paper by F. C. Miller to be presented at the Colrado meeting of the A.I.M.E. September, 1918.



INDUSTRIAL MAP OF COLORADO

Ore Treatment in Colorado

A Unique Position Has Been Maintained by Colorado in the Milling and Metallurgical Field—In Concentration, Smelting and Refining, Many Fundamental Improvements Are Due to Colorado Engineers

COLORADO has been prominent in the development of methods of ore treatment. The great variety of its minerals, the diverse conditions of locality, and its distance from manufacturing centers necessitated the development of methods that would result in finished or, as far as possible, nearly finished, metallic products that could be transported at a minimum of expense to the distant market centers. This progress, accelerated as new ores were discovered, stimulated the mining-machinery business. As a result, Denver became an equipment center of considerable importance. Metallurgists, chemists and millmen also developed under the stimulus of the important problems that they were compelled to solve. Innovation in the application of chemical principles and the development of mechanical appliances have long been features of the professional metallurgical practice that has made Denver a center for technical men. As a supply point, Denver has been for years and will continue to be important.

Amalgamation and Concentration

The first gold vein discovered in Colorado was the Gregory, at Black Hawk, Gilpin County, on May 6, 1859. Other discoveries followed, and soon Gilpin County was an important gold-producing area. The slow-speed, high-discharge stamp mill was developed in response to the early discovery of the fact that fine division and intimate contact with mercury were necessary for a substantial recovery of the gold.

Concentration by means of the Gilpin County bumping table opened the way to a new principle. The rapid development of lead smelteries afforded an outlet for the concentrates produced. Gilpin and Clear Creek counties became a Mecca for millmen, and the practice there established became the inspiration and example for other mining camps.

Concentration became the accepted method to apply to gold ores after amalgamation, and there are a number of plants wherein this combination method is still used. The accompanying list has been compiled to indicate the present position of the method. Better concentration appliances have taken the place of the old bumping table —the vanner, and tables of the Card, Wilfley, Overstrom and Deister types.

Concentration

Gilpin County practice was adopted, in some of its features, when lead, zinc and silver sulphide ores were discovered. Such ores were more complicated than the simple sulphide gold ores, and required a more thorough development of concentration appliances. The vanner was borrowed from California practice and served a useful end. In 1896, Arthur R. Wilfley invented the Wilfley table and greatly extended the possibilities for the treatment of the mixed sulphide ores that were so characteristic of the mining districts of Colorado. Classification and fine crushing were developed, and finally complete mill systems were worked out. Magnetic concentration for separating iron and zinc concentrates was applied. Electrostatic separation also was tried. Dry concentration methods were experimented with. Nothing that might give a more marketable product was ignored. Millmen tried and succeeded fairly well in sending clean concentrates of zinc, lead, and iron to the smelting plants. Flotation was welcomed as a method of insuring better recoveries and became important as a treatment to supplement the more common methods of wet concentration. The introduction of flotation was rapid, and the peculiar problems that were encountered necessitated a large amount of patient experimentation. The following list of plants indicates the present importance of concentration and flotation practice:

COLORADO AMALGAMATION-CONCENTRATION PLANTS

	Capacity
A. K. R. Gold Mining and Milling Co., Rollinsville	(a)
American Gold Mining Co., Ouray	(a)
Capital Mining and Tunnel Co., Georgetown	250-ton
Carr Mines, Central City	50-ton
Carter Mining Co., Ohio	20-stamp
Colorado Metals Co., Silverton	20-stamp
Continental Mines, Power and Reduction Co., Idaho Springs	100-ton
Dorit Mining, Milling and Tunnel Transportation Co., Idaho Springs	50-ton
Dumont Mining and Milling Co., Dumont	75-ton
Gilpin-Eureka Mines Co., Central City	10-stamp
Gold Anchor, Alice	10-stamp
Golden Age Mining and Reduction Co., Jamestown	50-ton
Golden Empire Mining Co., Empire	10-stamp
Intersection Leasing Co., Animas Forks	10-stamp
Jurich Mining and Leasing Co., Ames	30-stamp
Little Mattie Mining, Milling and Power Co., Idaho Springs	40-stamp
London Mining and Reduction Co., Alma	20-stamp
Meteor Mine, Alice	5-stamp
Miller Gold Mining, Milling and Tunnel Co., Leadville	15-stamp
Mount Champion Mining Co., Leadville	100-ton
Ophir Loop Mines Co., Ames	50-stamp
Pennsylvania-Colorado Mining, Tunnel and Milling Co., Central City	50-ton
Perigo Mines, Gilpin	30-stamp
Pioneer Consolidated Mines Co., Breckenridge	20-stamp
Raymond Cons. Mining Co., Ohio	20-stamp
Sunnyside M. and M. Co., Eureka	200-ton
V. P. R. Leasing Co., Central City	45-stamp

(a) Unknown

CONCENTRATION PLANTS OF COLORADO

	Capacity, Tons
Ackron Mines, White Pine	(a)
American Rare Metals Co., Cedar	10
Bard Creek Mining Co., Georgetown	50
Big Five Mining Co., Idaho Springs	50
Blue Flag Gold Mining Co., Laurium Mine, Breckenridge	75
Bolivar Mining and Tunnel Transportation Co., Montezuma	50
Denver Mining and Milling Co., Wortman	50
East Willow Mining Co., Creede	50
El Monte Mining and Milling Co., Jaspar	50
Canon City Mill, Empire Zinc Co., Canon City	200
Eagle Group, Empire Zinc Co., Gilman	150
Golden Sun Tunnel and Mining Co., Tolland	50
Granite Tunnel Co., Granite	50
Grimm Mill, Boulder	40
Hahn's Peak Gold Mining and Milling Co., Columbine	50
Highland Mary Mines Co., Animas Fork	(b) 20
Jessie Consolidated Mines Co., Breckenridge	100
Joe Reynolds M., M., Drainage Tunnel and Transportation Co., Idaho Springs	50
Keystone Mining and Reduction Co., Magnolia	50
Long Chance Mining Co., Nederland	30
Midland Chief Mines Co., Georgetown	50
Mineral County M. and M. Co., Creede	300
Orient Mine, Villa Grove	50
Philadelphia Mines Leasing Co., Montezuma	100
Pittsburgh Con. Mining, Milling and Tunnel Co., Idaho Springs	50
Rawley Mining Co., Bonanza	100
Rico-Wellington Mining Co., Rico	75
St. John Mines, Ltd., Revenue Mine, Ouray	250
Santiago Consolidated M., M. and Tunnel Co., Georgetown	50
Silver King Mines, Dumont	25
Smuggler Leasing Co., Aspen	400
Standard Gold-Copper M. and M. Co., Salida	(b) 10
United Imperial Mining Co., Georgetown	50
Wagner Development Mining Co., Telluride	100
Wasatch-Colorado Mining Co., Silver Plume	50 & 75
Wellington Mines Co., Breckenridge	150
Western Chemical Manufacturing Co., Denver	100
Western Gold Mining Co., Alma	25
Yellow Jacket Mines Co., Ouray	150

(a) Unknown
(b) Stamps.

COLORADO FLOTATION AND CONCENTRATION PLANTS

	Capacity, Tons
Allgrove M. and M. Co., Cardinal	75
American Metal Co., Ltd., Climax	250
American Metal Producing Co., Black Hawk	50
Argo Reduction & Ore Purchasing Co., Idaho Springs	100
Aspen mine, Silverton	150
Atlas Mining and Milling Co., Sneffles	150
Barstow Lease, Ironton	200
Big Giant Lease, Silverton	50
Broderick M. & M. Co., Idaho, Springs	50
Carribeau Mining Co., Ophir	50
Colorado Superior Mining Co., Telluride	200
Colorado-Utah Operating Co., Lake City	100
Contention Mining Co., Silverton	50
Evergreen Mines Co., Apex	100
Excelsior Mining, Milling and Electric Co., Excelsior Mine, Frisco	100
Genesee Mines, Ironton	50
Gold Crown Mining and Reduction Co., Ouray	100
Gold Hill Concentrating Co., Gold Hill	150
Gold King Leasing Co., Silverton	(a) 80
Hamlet Mining and Milling Co., Howardsville	100
Hudson Milling Co., Idaho Springs	125
Idaho Mining and Leasing Co., Hesperus	50
Idaho Mining, Reduction and Transportation Tunnel Co., Idaho Springs	50
Iowa-Tiger Mining Co., Silverton, (100-ton concentration; 50-ton flotation)	125
Kittimac Mine and Mill Co., Silverton	56
Little Giant Gold Mining and Milling, Lawson	175
Mary Murphy Gold Mining Co., Romley	500
Mears and Wilfley, Silverton	50
Mineral Farm Mine, Ouray	50
Mountain-Top Mining Co., Sneffles Milling Co., Idaho Springs	(a) 10
Oneida-Stag Mining Co., Idaho Springs	100
Paramount Reduction Co., St. Elmo	100
Pine Marten Mining Co., Red Cli.	200
Pingrey Mines and Ore Reduction Co., Leadville	100
Pride of the West Mining Co., Howardsville	250
Progress Mining and Milling Co., Frawley	50
Puzzle Leasing Co., Breckenridge	250
S. D. and G. Leasing Co., Silverton	100
St. John Mines, Ltd., Denver (Comstock)	100
Silver Ledge Mine, Silverton	300
Silver Lake Mines, Silverton	600
Sunnyside M. & M. Co., Eureka	50
Vernon Mining Co., Ironton	350
Vindicator Gold Mining Co., Independence	

(a) Stamps.

CHLORINATION

The Plattner process for the treatment of gold ores was invented in 1848. Colorado metallurgists developed it and erected plants and treated ores on a scale that attracted the attention of their brother workers in all parts of the world. Mechanical roasting furnaces, the Holthoff-Wethey, the Pearce turret, the Ropp, the Brown, the Jackling and the Argall, were designed and used on a large scale. Roasting practice became systematized.

Barrel chlorination was rapidly advanced to complete development and became standard practice in the chlorination mills treating ores in the Cripple Creek district and at Colorado City. In 1900, the popularity of chlorination began to wane, and its active competitor, the cyanide process, slowly pushed it out of the field. In 1897, Philip Argall was operating the Metallic Extraction Co.'s plant, nearer Florence. In 1901 the Dorcas cyanide plant was in operation. By 1910 there were only two chlorination plants in operation on Cripple Creek ores. The magnificent installations at Colorado City finally shut down, the last one in 1912, leaving the field to the smelteries and cyanide plants.

CYANIDATION

Philip Argall became interested in the application of the cyanide process to gold ores in the Cripple Creek district, and his efforts led to such success that the new process entirely displaced chlorination. Wherever gold ores were encountered in Colorado, the cyanide process established itself. The Portland cyanide plant at Victor was especially designed to treat the low-grade dump rock that had accumulated for many years. It was a success and has attracted the attention of metallurgists in other localities. For the treatment of higher-grade ores, the Golden Cycle plant at Colorado Springs is a typical example. The importance of the method is indicated by the number of plants that have been constructed.

CYANIDE PLANTS OF COLORADO

	Capacity, Tons
Blue Flag Mine (Blue Flag Gold Mining Co.), Cripple Creek	100
Camp Bird Mine (inactive)	250
Commonwealth Mining Co., Alma	40
Dante Gold Mining Co., Cripple Creek	100
Golden Cycle M. and Reduction Co., Colorado Springs (roast cyanide)	1300
Isabella Mines Co., Victor	75
Jerry Johnson Gold Mining Co., Cripple Creek	100
Joe Dandy Mining Co., Cripple Creek	100
Liberty Bell Gold Mining Co., Telluride	500
London Badger Gold Mining and Milling Co., Ophir	(a)
Portland Gold Mining Co., Victor, (600-ton concentrating mill and cyanide plant; 1400-ton concentrating and cyanide plant; 400-ton cyanide plant)	
Queen Gold Mining Co., Cripple Creek	200
Rex Mining and Milling Co., Victor	100
Smuggler Union Mining Co., Telluride	600
Tomboy Gold Mining Co., Ltd., Telluride	500
United Gold Mines Co., Cripple Creek	50
United States Gold Corporation, Sugar Loaf	150
Wano Mining and Milling Co., Jamestown	50

LEAD-SILVER SMELTING

Colorado early became a lead-silver smelting center, and the practice developed there was in advance of that of any other district. From the earliest days of Leadville there was steady progress. Each smelting plant that was erected was an improvement, mechanically and metallurgically, over its forerunners. Ore tonnages offered to the smelters were never large and probably seldom exceeded 600,000 tons per annum, and much ore from neighboring states was necessary to smelt the Colorado ores. The principal factor in developing the custom-smelting industry can be traced to the necessity of bringing other ores to the furnaces for fluxing and for maintaining the proper proportion of lead in the charges.

Lead-silver smelting has had its ups and downs in Colorado, and new ore discoveries may be expected to maintain the industry. The present smelting capacity is confined to five plants, of which four are operated by the American Smelting and Refining Co. A brief description of the plants follows:

Globe Smelter, Denver: 7 blast furnaces; total annual smelting capacity, 510,000 tons.

Pueblo Smelting and Refining Co., Pueblo: 7 blast furnaces; total annual smelting capacity, 380,000 tons.

Durango plant, Durango: 4 blast furnaces; annual capacity, 210,000 tons.

Arkansas Valley Smelter Co., Leadville: 10 blast furnaces; annual capacity, 510,000 tons.

Ohio & Colorado Smelting Co., Salida: 4 blast furnaces; annual capacity, 345,000 tons.

MATTE SMELTING

The smelting of copper ores with gold and silver ores, collecting the gold, silver and copper in a matte, was begun in 1878 by Richard Pearce at the Argo works, a smaller smelting plant having been operated at Black Hawk before this time. A highly successful practice was established. Small reverberatories, 9.75 x 15 ft., were first used, and these were increased in size until in 1894 they were 16 x 35 ft. A unique system of refining the copper matte for its gold content was put in successful operation, and remained a metallurgical secret until the Argo plant was closed down, when the details of the method were disclosed.

Pyritic smelting was introduced into Colorado early in 1892 at Leadville and at Kokomo. F. R. Carpenter established plants at Golden and at Florence. Similar smelteries were built at Leadville, Ouray and at Vulcan. Most smelters were successful to a moderate extent, although they did not establish the pyritic method of

smelting as firmly as was the case of the silver-lead smelters with their method.

As the copper ores of the state, never very great in quantity, diminished, both pyritic and matte smelters had to secure ores from outside the state. Confronted with the added difficulty of finding a market for their matte, they finally succumbed.

Zinc Smelting

The presence of a large proportion of zinc sulphide in many of the ores of Colorado made such ores objectionable to the lead smelters, and caused them to impose severe penalties upon high-zinc ores. To lose not only the value of the zinc but also to receive less for his lead was not particularly attractive to the miner. The result was to stimulate metallurgists to discover methods for the separation of the lead and zinc compounds.

Bartlett, at Canyon City, introduced a method of volatilizing and burning the zinc to an oxide by means of a special furnace. The zinc oxide mixed with some lead sulphate was marketed to paint manufacturers, and the residues were worked up for gold, silver, copper and the remaining lead. A successful business was established and continued for a number of years.

Other metallurgists attacked the problem by mechanical separation. Electro-magnetic separation was eventually established, and certain ores responded to treatment by this method. The U. S. Zinc Co., the Western Chemical Co. and the Empire Zinc Co. have magnetic separators in their mills. Electrostatic separation was early tried out and has not been particularly successful. Until recently there was a plant in operation in Denver, and three others in the state. Differential flotation has also been tried and is no doubt successful in a number of mills. What has been demonstrated is that no one method is equally applicable to all ores, but is, rather, applicable only to ores of a certain type. The zinc-lead sulphide problem has not been completely solved, but satisfactory results are being obtained in a number of instances. Low-zinc lead concentrate and low-lead zinc concentrate are now being marketed where formerly an almost unmarketable product was shipped.

At Leadville a zinc-oxide plant is treating zinc carbonate ores. The River Smelting and Refining Co.'s plant treats zinc-lead-copper sulphide ores from several counties in Colorado, a part of its product being forwarded to this company's electrolytic zinc plant at Keokuk, Iowa. The U. S. Zinc Company's plant at Pueblo is operating 2320 zinc retorts and producing zinc from ores from Colorado and other districts.

Radium, Uranium and Vanadium

Colorado has produced some unusual ores, chief of which are carnotite and pitchblende. The successful treatment of these by scientists of the U. S. Bureau of Mines is so recent that it is unnecessary to go into detail here. Radium, sodium uranate, and iron vanadate have been produced in quantity by methods that were devised in a Denver plant. In another part of this issue an abstract of Dr. R. B. Moore's paper on the methods of treatment of carnotite ores is presented.

The war demand for tungsten stimulated the mining of tungsten ores. The Boulder district is the most important producer. The dressing practice for the special treatment of these ores has progressed until results have been greatly improved. Ferrotungsten, ferrochrome and ferromanganese are being produced by Colorado plants. In another part of this issue Robert M. Keeney describes the smelting methods in use. The activity in the production of tungsten and rare metals is shown by the list of operating companies that follows:

TUNGSTEN, CARNOTITE AND RARE-METAL COMPANIES OF COLORADO

(Figures in parentheses denote capacity)

American Rare Metals Co., Cedar
Black Metal Reduction Co., Boulder (Tungsten concentrate and slime refinery)
Black Prince Mines, Ferberite (15-ton)
Boulder Tungsten Production Co., Boulder (50-ton)
Tungsten Ref. and Ext. Plant, electric furnace (25-ton), Manufacturers. ferro-tungsten tungstic acid
Carnotite Reduction Co., Nucla
Colorado-Gilpin Gold and Radium M. Co., Central City
Eagle Rock Tungsten Production Co., Boulder (75-ton)
Ferro Alloys Co., Denver (manufacturers of ferrotungsten)
Rare Metals Ore Co., Denver and Rollingaville
Intermountain Tungsten Milling Co., Saline (50-ton)
Iron Mountain Alloy Co., Denver
Long Chance Mining Co., Nederland (30-ton)
McKenzie Mines, Nederland (20-ton)
Colorado Metal M. and Red. Co., Georgetown, (20 stamps)
Mohave Boulder Tungsten Co., Sugar Loaf (50-ton)
National Tungsten Mining Co., Rowena (25-ton)
Overall Mines Co., Egnar (carnotite)
Pittsburgh Radium Co., Denver
Primos Chemical Co., Vanadium
Primos Exploration Co., Crescent (35-ton)
Primos Mining and Milling Co., Lakewood (60-ton)
Radium Ores Co., Naturita
Rare Metals Ores Co., Rollinsville (75-ton)
Schlesinger Radium Co., Paradox (10-ton)
Standard Chemical Co. (50-ton)
Sugarloaf Tungsten, M., M. and Dev. Co.
Tungsten Metals Corporation, Boulder (25-ton)
Tungsten Mountain Mines Co., Tungsten
Vasco Mining Co., Boulder (two 50-ton)
Wolf Tongue Mining Co., Nederland (50-ton)

Technical Uses of Radium*

The chief technical use for radium is in connection with permanently luminous paint. If radium salts are mixed with phosphorescent zinc sulphide, a product is obtained which is permanently luminous in the dark without previous exposure to light. The zinc sulphide must be specially prepared and usually contains traces of impurities, such as copper, manganese, or other mineral. Just what relation exists between these impurities and the peculiar properties of the zinc sulphide is not known, although experimental work is now being done to determine it. The luminous paint usually carries from 0.1 to 0.25 mg. of radium element to 1 gram of zinc sulphide, depending upon the particular use to which the paint is put.

This material is now being used largely on the faces of watches and clocks; to coat electric light push-buttons and the chains attached to electric globes; and for various other purposes. It is unfortunate that the domestic supply of radium is being disseminated in this manner. But as the physicians and surgeons of the country are not purchasing enough radium to made the industry a financial success, it is natural that the manufacturers should take other means of creating a demand. The day is probably not far distant when the people of the United States will greatly regret that so much radium has been utilized in this way.

Radium has a most decided usefulness at present; nine instruments used on airplanes have dials made luminous with radium paint, and it is employed in the same manner for compasses and gunsights. The efficiency of night firing, with both machine guns and artillery, has been greatly increased by the use of luminous sights. Other uses cannot be specified, at the present time, in a public paper.

*An excerpt from a paper presented at the Colorado Meeting of the A. I. M. E. by Richard B. Moore, of the U. S. Bureau of Mines.

Headquarters of the A. I. M. E.

DR. R. W. RAYMOND'S OFFICE

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Radium Ore Deposits*

Carnotite Occurrences of Colorado and Utah Are of Great Importance in the Production of Radium Compounds—Scattered Deposits in Dolores, San Miguel and Montrose Counties

By RICHARD B. MOORE

THE principal commercial ores of radium are pitchblende and carnotite. The former mineral has no definite composition, consisting of uranium oxides (UO_3, UO_2) with oxides of lead, calcium, iron, bismuth, manganese, copper, silicon, aluminum, and rare earths. Carnotite has a more definite composition, being a potassium uranyl vanadate containing small quantities of barium and calcium. The formula $K_2O.2UO_3.V_2O_5.3H_2O$ expresses its composition fairly well, although not exactly. Of lesser importance are autunite, a hydrated calcium uranium phosphate $Ca(UO_2)_2(PO_4)_2.8H_2O$, and torbernite, a hydrated copper uranium phosphate $Cu(UO_2)_2.P_2O_5.8H_2O$.

The pitchblende deposit at St. Joachimsthal, Austria, is in mica schist interbedded with lime schist and crystalline limestone. Toward the east and northeast the formation is gneiss. The gneiss was intruded by quartz porphyry subsequent to the deposition of the vein material. In the mica schist are fissures filled with volcanic material which cut the mineralized zone at various points and depths. The veins are usually 6 in. to 2 ft. wide, in rare cases widening out to 3 ft. The mode of mineralization varies greatly, the ores occurring in both stringers and pockets. They contain silver, metallic and as argentite; polybasite, tetrahedrite, etc.; nickel, as nickelin, chloanthite, etc.; cobalt, as smaltite, bismutosmaltite, etc.; bismuth, as metallic bismuth, bismite, etc.; arsenic, as metallic arsenic and arsenopyrite; and uranium, as pitchblende and other alteration products. Galenite, zinc blende, pyrite, marcasite, and copper occur in minor quantities. The veins show that deposition occurred in three periods; the cobalt and nickel were deposited first, then the uranium, and lastly the silver. Dolomite spar is always present, and generally has a white or yellowish-white color, but changes to a brownish-red hue where pitchblende begins to appear, and is a dirty gray where it is actually in contact with the ore. Deep-blue fluorspar is always present. The mines at Joachimsthal have been worked since 1517. In 1545 the production of silver ores declined considerably, but since then the deposits have been mined for bismuth and cobalt. During the last 25 years the mines have been worked for uranium.

Saxony Silver-Cobalt Ores

In the vicinity of Annaberg, on the Saxony side of the Erzgebirge, the silver-cobalt veins resemble those at Joachimsthal. At Johanngeorgenstadt, the veins contain tin and silver-cobalt ores. Where dolomite spar is found, the silver-cobalt ores contain pitchblende, as at Annaberg. In the Gottessegen mine the pitchblende occurs in the spar in pieces 2 to 3 in. in diameter. These mines are worked principally for bismuth ocher, but also for cobalt and nickel. In the cobalt-bismuth mines of Schneeberg are found bismutite and various minerals of nickel, silver, and arsenic. There is also some pitchblende, uranochalcite, uranospinite, galenite, and zinc blende.

The Cornwall Pitchblende

Pitchblende has also been found in Cornwall, England, in the tin region. At Joachimsthal and Johanngeorgenstadt, the mineral is found associated with nickel-cobalt veins, though only part of the veins are highly argentiferous. Even though these veins are closely connected with the tin veins, they apparently are not of the same age as the latter, but belong to the same general period of mineralization.

Pitchblende in the United States

Pitchblende has been found in the following localities in the United States: Feldspar quarry, at Middletown, Conn., in large octahedrons; in Hall's quarry, at Glastonbury, Branchville, Conn., in a pegmatite vein and usually embedded in albite; at Marietta, S. C.; in the Baringer Hill district, Llano County, Tex.; in the Bald Mountain district, Black Hills, S. D.; in Mitchell County, N. C.; and in Gilpin County, Colo. The latter district is the only one of commercial importance.

All of the Gilpin County mines, with one exception, are found on or near Quartz Hill, a few miles from Central City. There are five that have produced pitchblende in quantity: the Kirk, Wood, German, Belcher, and Calhoun. The Kirk, Belcher and German mines are close together on Quartz Hill; the Wood and the Calhoun are in the valley below.

These mines until recently were worked mainly for gold. In this district, gneiss and crystalline schist predominate, with intrusive andesitic dikes and occasionally acid granitic dikes. The rock containing the pitchblende, galena, sphalerite, etc., is a fine-grained aplitic granite which probably once contained an appreciable amount of biotite. The ore deposits are of two general types, one containing pitchblende with pyrite, sphalerite and galena, and sometimes marcasite; and the other type carrying pyrite, chalcopyrite, sphalerite and galena, with some gold and silver. Generally speaking, the two types are not associated, so that the miner has a choice of mining either for pitchblende or for gold.

The Kirk mine has probably been the most important producer of the five mentioned, although reliable data on the output of pitchblende from this mine, up to a few years ago, have been difficult to obtain. During the last 12 years, about 20 tons of ore, with an average content of 35% U_3O_8, and over 100 tons with a content of 3 to 4% U_3O_8, has been mined. The mine has been shut down for some time. More recent operations of the German and Belcher mines produced 120 tons of low-grade ore, averaging about 1% U_3O_8, and six tons

*An excerpt from a paper presented at the Colorado meeting, September, 1918, of the American Institute of Mining Engineers.

of high grade. Smaller quantities of ore have been produced at various times from these mines and from the Wood and the Calhoun.

Uranium ores are found in certain localities in Australia. One of these deposits is 80 miles east of Farina, a railroad station on the Great Northern line, in South Australia, and lies between Mount Painter and Mount Pitt. H. L. Y. Brown states that the rocks of the district consist of coarse and fine feldspathic, siliceous, and micaceous granite, gneiss, quartzite and mica schist. The rocks are contorted in places and penetrated by dikes of coarse, pink-colored eruptive granite.

Portugal Autunite

Autunite is found in commercial quantities in Portugal in the district between the towns of Guarda and Sabugal. Apart from the uranium, the rocks of the region are much mineralized, showing deposits of galena, arsenopyrite, chalcopyrite, tungsten and cassiterite. All of the deposits referred to are important and have been developed as commercial sources of radium; in fact, until about seven years ago, they were the only source from which radium ores were obtained.

Carnotite Deposits of Colorado and Utah

About 1910, the carnotite deposits of southwestern Colorado and eastern Utah began to receive attention. They were known as far back as 1881, but the composition of the ore was unknown until 1897. In 1899, an analysis showed that the ore not only contained uranium, but was a potassium uranyl vanadate. In 1900, a small plant was erected in the McIntyre district, south of the Paradox Valley, Colorado, for the extraction and recovery of uranium oxide from carnotite ore. Only moderate success was achieved, and the plant was soon shut down. Operations were also started by other concerns, notably the Western Refining Co. and the Dolores Refining Co. These plants extracted uranium and vanadium only. None of these operations was of importance, and it was not until 1909 or 1910 that any interest was shown in the carnotite deposits as a source of radium. At that time, the ore was almost exclusively shipped abroad.

In the autumn of 1912, representatives of the U. S. Bureau of Mines made a thorough survey of the carnotite fields and announced the fact that the carnotite deposits of Colorado and Utah constituted by far the largest source of radium-bearing ores in the world. Developments since then have proved this statement to be correct, as the larger part of the radium that has been produced up to this time has been derived from American carnotite ore.

Carnotite Area 60 by 20 Miles

The deposits are found mainly in Dolores, San Miguel, and Montrose counties, Colo., and extend over a belt about 60 miles long by 20 miles wide. The ore is also found to the west of the La Sal Mountains in Utah, and along the San Rafael Swell, southwest of Green River, Utah. Small patches of ore are found scattered between these points and extend up as far north as Meeker, Colorado.

The most usual ore is a sandstone so impregnated with yellow carnotite that the color is decidedly noticeable, and contains small kidneys of brown sandy clay. The kidneys constitute a considerable part of some of the ore; in many cases they are thinly scattered through the sandstone. Although ore of the character mentioned is widely distributed in the Paradox and adjacent districts, and constitutes a large part of the ore shipped, it is by no means the only ore of commercial importance. Indeed, the variety of the types of ore in Utah is one of the interesting features of the uranium and vanadium deposits. There are dark blue, brown, and black vanadium ores, the dark blue ores being lustrous when first mined and usually carrying uranium; high-grade carnotite in vug holes so soft that it can be molded in the fingers; and the same kind of ore crystallized with gypsum. Red calcium vanadate is found alone and mixed with carnotite. The ores of the Paradox district differ in many respects from those in Utah, but chiefly in carrying larger proportions of carnotite, and as a rule are more yellow. Not only do they carry more uranium, but also, on the average, more vanadium, although individual shipments from Utah, particularly from Temple Mountain, might seem higher in vanadium than the average ore from the Paradox district.

The deposits are invariably pockets, many of which, however, are of considerable size. A few individual claims have produced as high as 500 tons of shipping ore, but this is an exceptional condition. The ore is found in a light-colored sandstone overlain in places with shale and conglomerate; according to Hillebrand and Ransome, this is the McElmo formation.

Future Supply of Ore

It is difficult to estimate the exact amount of radium in existence at the present time; probably it is somewhere around 3 oz. of radium element. On account of the great scientific interest attached to radium, and because of its use in the war and in medicine, the permanency of the ore supply is an important question. Considerably more than half the amount of radium now in existence has come from Colorado and Utah carnotite ores. Six years ago, the engineers of the Bureau of Mines estimated that, at the current rate of production, the deposits might last, commercially, 10 or 12 years. At the present time, it is difficult to obtain ore. Most of the deposits are owned by five operating radium companies. The production has increased greatly during the war; and I am doubtful whether it is possible to depend upon American carnotite deposits to yield commercial quantities of ore for more than six or seven years longer. It is my judgment that the fields will not produce more than 100 additional grams of radium element at the most—if that much. This would about double the world's present supply; but, on account of the large use of radium in cancer treatment, such an amount, although large scientifically, would be small in proportion to the probable demand.

RADIUM PRODUCTION FROM AMERICAN CARNOTITE

Year	Tons U_3O_8	Tons U	Grams Ra Contained	Grams Ra (Recovered, 75% Basis)
1912	28.8	24.4	7.4	5.5
1913	41.0	34.8	10.5	7.9
1914	87.2	74.0	22.5	16.9
1915	23.5	19.9	6.0	4.5
1916				
1917	70.0	59.3	18.0	13.5

Molybdenite Operations at Climax, Colorado*

BY D. F. HALEY

Molybdenite deposits at Climax, Colo., have recently attracted considerable notice, because of their great size, as compared with other known deposits of the same mineral. Climax station is 14½ miles northeast of Leadville, and is 11,300 ft. above sea level. Climatic conditions are severe, and snow may fall in any month.

Some of the richest gold placers of Colorado occur within a few miles of Climax, so the surrounding country has been well prospected, although it is difficult to say when the presence of molybdenite first became definitely known. Claims had been staked as early as 1896, but it is evident that the prospectors at that time were looking for gold.

In 1916, engineers of the American Metal Co. made a thorough examination of the property. They had difficulty in getting concordant results from different assayers, and the return varied between 0.4 and 1.2%. Finally, by systematic sampling and testing, a product of the property was put through flotation machines and a concentrate was obtained, assays of which showed that a recovery of 12 lb. of MoS_2 per ton of ore could reasonably be expected.

The orebodies are found on the southwestern slope of Bartlett Mountain, which consists of alaskite, or highly siliceous granite. Many inclusions of gneiss are found in the alaskite, and on the western flank of Bartlett Mountain thick limestone beds occur, tilted at such an angle as to indicate that they at one time covered the area, but have been removed by erosion. The gneiss may be an altered sedimentary rock. Glacial action has evidently been severe, and the divide is covered by a heavy moraine.

The ore occurs as an intricate system of fine stringers fairly evenly distributed throughout the alaskite. The original granite has been altered and silicified, and appears now to consist only of a quartz ground-mass in which some phenocrysts of feldspar still remain. Little ore mineral is found in the quartz-porphyry occurring throughout the main ore-bearing rock. Associated minerals are iron pyrite and a small amount of copper. Occasionally a small pocket of hübnerite is found, but not in appreciable amounts.

Two systems of mining are practiced. The thin outer edge of the orebody, bounded by the horizontal plane of the tunnel and the steep sloping surface, is to be removed by open-pit gloryhole methods during the summer months. Drifts have been run 40 ft. below the surface and parallel to the contours of the hill. From the drifts, raises will be driven to surface, and the ground broken down through them, drawn into cars and trammed out to the bins. Further in, the ground has been laid out in a series of parallel drifts running diagonally across five parallel patented claims. These drifts are 50 ft. apart and 860 ft. long. From them, raises are put up every 30 ft. and widened out, above the back of the level, to a cone-shaped pocket, at the bottom of which a chute is placed. This widening connects all of the pockets, and, when completed, is ready for shrinkage operations.

The stope drift is 860 ft. long and the stope itself is carried up as two separate workings, each 400 ft. long and 25 ft. wide. In the center, between the stopes, a pillar 40 ft. long is left standing. A two-compartment raise is carried up ahead of the stope through the center of this pillar, and small drift holes are extended from the raise to the stopes on each side about every 20 ft. At the end of each stope, a similar pillar is left, through which a one-compartment raise is carried up, which is connected with the stopes by small drifts. The stopes are to be carried up to the surface as shrinkage stopes, and when the surface is reached, the end and side pillars left between the stopes will be broken down by gloryhole methods.

The ore from the mine is dumped into a 300-ton bin, from which it is drawn into the one-ton buckets of a 700-ft. Leschen jig-back tram. This delivers it to two 400-ton bins, so designed that both bins feed into a 10 x 20-in. Blake crusher. From the crusher, the ore drops on a 16-in. conveyor belt, is elevated to a 400-ton tramway bin and carried to the 500-ton mill bin by means of a 4700-ft. Leschen aërial tramway. The ore is fed by plunger feeders to a 16-in. flat conveyor belt, which delivers to an Allis-Chalmers ball mill. From this 6 x 6-ft. mill, the ore (now crushed to about 20 mesh) goes to a standard duplex Dorr classifier. The overflow goes direct to the flotation machines, and the sands drop to a 6 x 10-ft. Allis-Chalmers ball mill and return to the same classifier until fine enough for overflow. Crushing is to 120 mesh.

The flotation plant consists of five Janney air-mechanical machines, three Callow standard roughing cells, and two Callow one-half-size cleaner cells. The first four Janney cells deliver rough concentrates to the fifth cell, for partial cleaning; cell No. 4 discharges tailings, and the discharge from No. 5 consists of middlings, which are returned to the circuit. The concentrate from No. 5 goes to the first Callow cleaner; the concentrate from this goes to the second Callow cleaner; and in order to improve the grade, one of the Callow roughers has been converted to a third cleaner. The mill is putting through 300 tons daily.

The flotation operation is delicate, as there is nearly three times as much pyrite in the ore as molybdenite, and with a concentration ratio of 115 or 120 to 1, a large portion of the iron must be dropped to get a concentrate carrying from 65 to 70% MoS_2. Another difficulty is that when treating, say, 300 tons per day, carrying 0.92% MoS_2, the resulting concentrate, on present recovery, amounts to only 5100 lb. of 65% product, or only about 4 lb. per minute from the cleaner. The size of the cleaner has been reduced, but it still remains somewhat difficult properly to control the grade of the concentrate.

A vanner is being installed to treat the concentrate for the removal of pyrite, as each unit of iron removed will increase the grade of concentrate 2.2%, the concentrate now carrying about 10% iron. Mill recovery is now 60% of the total Mo in the feed, which is equivalent to a sulphide recovery of 82%. Many tests are being made, with encouraging results, for the recovery of the oxide molybdite. It is interesting to note that the feed to the mill averages almost exactly the figure originally estimated, the recovery being about 11½ lb. of MoS_2 per ton, as against 12 lb. estimated recovery.

*Abstract of a paper to be read at the Colorado meeting at the American Institute of Mining Engineers, September, 1918.

Mining in the Telluride District of Colorado

Climatic Conditions, and the Character of the Ore Deposits of an Important Colorado Mining District—Methods of Mining, With Particular Reference to Adit Driving

By HARRY J. WOLF*

THE first active search for precious metals in the Telluride district was probably about 1875. At that time locations were made on veins now worked by the Smuggler Union Mining Co. From 1875 to 1885 a considerable amount of prospecting was done and many mining claims were located, but early records indicate that the probable production during this period was less than $50,000. In 1890 the Rio Grande Southern R. R. was completed from Ridgway to the town of Telluride, and the camp began to attain importance. Previous to the opening of railway communication, only rich ore could be handled at a profit, because all ore mined was transported on pack animals over difficult trails to distant smelteries, and only light, crude mining equipment could be brought into the district.

SAVAGE BASIN. VIEW LOOKING SOUTHEAST AND SHOWING A PART OF THE TOMBOY SURFACE PLANT

Development Due Largely to Power Facilities

Since the completion of railroad communication with the smelteries at Salida, Pueblo, and Durango, the development of the district has been rapid. Large and efficient mining plants have been installed, many mills have been erected, and the old practice of packing out only rich crude ore at great expense has been replaced by the efficient local treatment of large tonnages of low-grade material, and the shipment of concentrate and bullion. Efficient local transportation has been developed by the construction of good trails, excellent wagon roads, and wire-rope tramways. Hydro-electric power has been developed to a high state of efficiency by that pioneer corporation in high-tension power transmission, the Telluride Power Co., which in its early stages of growth was under the skillful management of L. L. Nunn and Cooper Anderson.

The present city of Telluride, with a population of about 2000, is the county seat of San Miguel County, in southwestern Colorado, and is 422 miles from Denver by rail. Telluride is situated in the western part of the rugged district known as the San Juan Mountains and popularly referred to as the "San Juan Country." The city of Telluride, with Ouray, the county seat of Ouray County, and Silverton, the county seat of San

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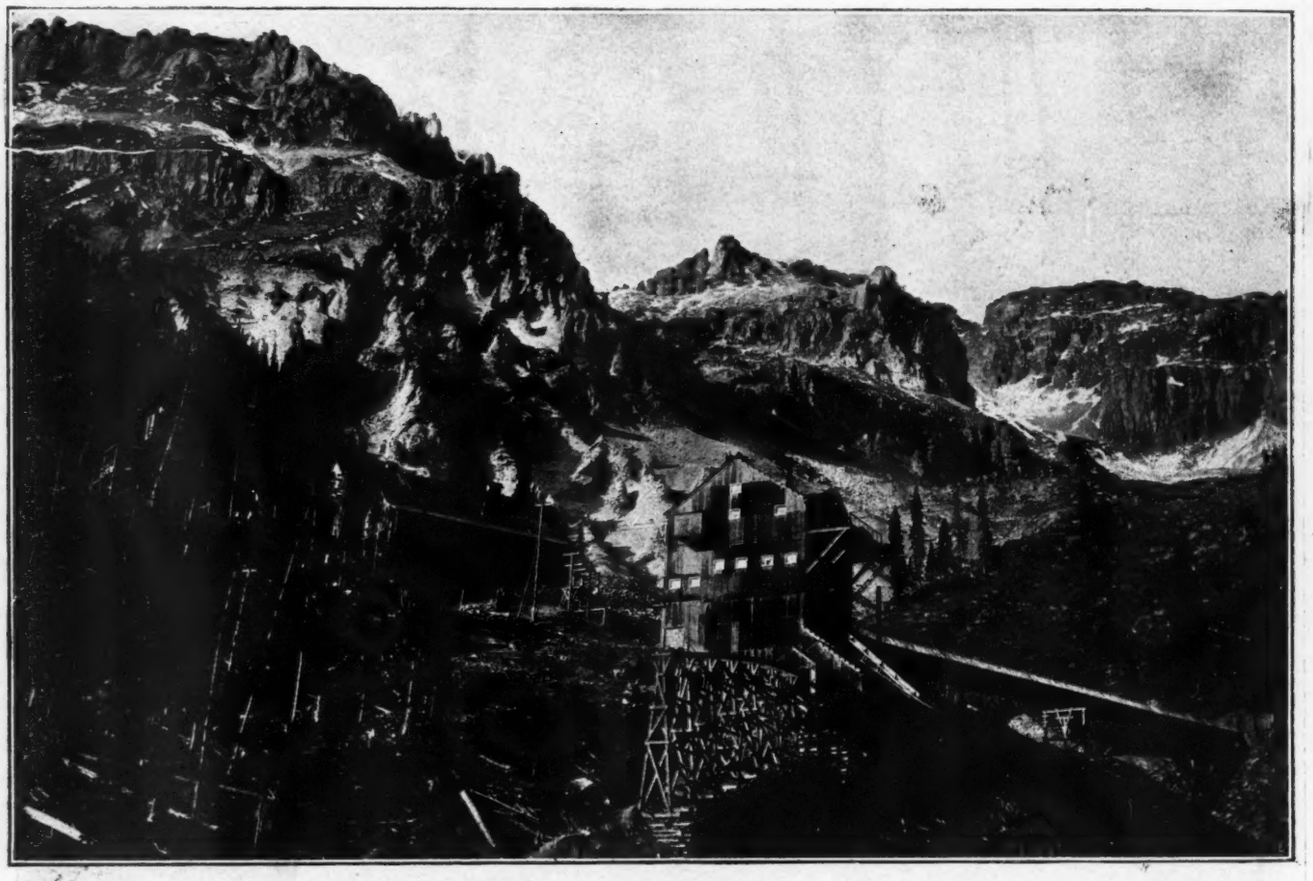
Juan County, forms the so-called "San Juan Triangle," famous for its production of both precious and base metals.

Geology of the Telluride District

The valley of the upper San Miguel River, in which Telluride is situated, with its tributary gulches, offers an excellent opportunity for the study of the geology of the district. The elevation of Telluride is 8756 ft., and the mountain ridges surrounding it on three sides rise to altitudes of over 13,500 ft. The deep gulches expose the edges of the horizontally disposed rock strata through a vertical distance of nearly 5000 ft.; and in many places vertical cliffs almost 2000 ft. high present to view several layers of the more important rocks. A generalized section of the sedimentary and bedded volcanic series of the locality is shown in the accompanying table, adapted from U. S. Geological Survey Folio 57.

SEDIMENTARY AND BEDDED VOLCANIC SERIES, TELLURIDE DISTRICT

Period	Formation	Thickness Near Telluride, Feet	Character of Rocks
Neocene and Eocene..	Potosi rhyolite	1,300	Rhyolite flows and tuffs
	Intermediate	200	Andesite and rhyolite
	San Juan	2,000	Andesite breccia
Eocene	San Miguel	500	Coarse conglomerate
	Unconformity		
Cretaceous	Mancos shale	300	Gray sandy shales
	Dakota	150	Gray or brown quartzose sandstone
	McElmo	600	Alternating sandstones and shales
Juratrias	La Plata	100	Two white sandstone beds, with dark limestone between
	Dolores	1,550	Red sandstone, grit, conglomerate and shale
	Alluvium		Lake and river deposits



LIBERTY BELL MINE, CORNET BASIN, TELLURIDE, COLORADO

The more conspicuous of the country rocks are the red sandstone and conglomerate, overlain by andesite, andesite breccia, and rhyolite in horizontally disposed layers. These rocks are cut by nearly vertical fissures containing mineral-bearing quartz. Strong fissures frequently cut through all the layers of country rock and continue to unknown depths, but the most important orebodies are found in veins in the andesite. Some orebodies have continued upward through the rhyolite, and occasionally downward into the conglomerate. In certain exceptional cases small deposits of payable ore have been found in the red sandstone and at the intersection of quartz veins with the limestone.

In the San Juan Mountains the important fissures may be classified in several well-defined systems, according to their strike and dip. In the immediate vicinity and to the northeast of Telluride, the fissures which strike northwest and southeast appear to be the most important from an economic standpoint. The strike of these ranges from N 25° W to N 50° W, and the dip is usually southwest.

Underground development is almost entirely by adits driven on the veins into the steep sides of the mountains. Frequently crosscuts are driven from the surface to cut veins that strike parallel to the mountain ridges, and occasionally shafts are sunk in country rock or on the veins, when such development is more practicable than the driving of an adit or crosscut. Some of the adits and crosscuts have attained considerable length, notably that known as the Revenue Tunnel, which is over 7500 ft. long, and cuts the Vir-

ginius vein at a depth below the surface of over 2000 ft. and at an elevation of about 10,800 ft. Development by long adits is usually the most practicable, not only on account of the topography of the country, but because of the heavy snowfall in the higher altitudes, the danger of snowslides, and the expense of transporting machinery and supplies into the upper basins. A record of the snowfall in Savage Basin during the winter of 1910-1911 shows a total of over 36 in. for the period from October 1 to June 16.

Mining Methods in Vogue

The customary methods of mining are by overhand open stopes, waste-filled stopes, or shrinkage stoping. The levels are usually supported by stulls and lagging of red spruce or white spruce timber. Occasionally pillars are left above the levels. Common stoping widths are 3 to 5 ft., rarely more than 8 ft., so that the vein walls may be supported by stulls where timber is used for this purpose. Frequently the narrow veins are mined by stripping methods.

Varieties of Ore Mined

The commercial ores of the district which carry chemically combined gold and silver are galena, argentiferous gray copper, polybasite, proustite, pyrargyrite, and stephanite. The metallic gangue minerals are, in addition to the above, iron pyrite, chalcopyrite, zinc blende, mispickel, magnetite, and native copper. The non-metallic gangue minerals are quartz, calcite, siderite, rhodochrosite, dolomite, fluorite, barite, sericite, biotite, chlorite, amphibole, apatite, garnet, orthoclase, and kaolinite. Payable ores are variable in composition, from a simple gold-bearing quartz to a complex mixture of lead, zinc, and iron sulphides, carrying small amounts of gold, silver, and copper.

Production of the District

During 1916 San Miguel County had 20 operating mines, and produced 428,651 tons of ore, having a total value of $3,319,676. The upper San Miguel mining district, which is immediately tributary to the city of Telluride, produced 424,794 tons of ore, yielding $2,057,586 in gold, 804,795 oz. of silver, 568,947 lb. of copper, 6,088,319 lb. of lead, and 1,098,485 lb. of zinc, with a total value of $3,294,393, as compared with $3,065,758 in 1915.

The bulk of the production of the Telluride district has been maintained by a few large mines, notably the Smuggler Union, the Tomboy, and the Liberty Bell. A brief description of a few of the more important properties will serve to illustrate the mining conditions and practices of the camp.

Smuggler Union Mining Company's Property

The Smuggler Union Mining Co. operates two mines—the Smuggler and the Humboldt. The property includes 77 patented claims, with an area of about 996 acres, located in San Miguel and Ouray counties. The ore carries gold, silver, lead, and iron, occurring in a quartz-filled fissure, with an average width of about 2½ ft. The vein cuts through andesite, tuff, and rhyolite for a vertical distance of over 2000 ft., strikes northwest and southeast, and dips to the southwest. The Smuggler mine is about four miles from Telluride at an altitude of 10,900 ft. The vein, which cuts through Marshall Creek Gulch and along the south side of upper Marshall Basin, is developed by adits, the lowest being over 3700 ft. long, from which is sunk a 280-ft. winze. The main haulage level is 3600 ft. long. The workings reach a maximum depth of about 2300 ft. The total workings aggregate over 30 miles. The mine is wet in the tunnels, but not in the stopes, from April until July.

The Humboldt mine is about six miles from Telluride, at an altitude of 12,000 ft. The workings are dry the entire year. The ore is transported from the mines over wire-rope tramways to the milling plant, which is on the railroad at Pandora, about two miles east of Telluride. The Smuggler mill is equipped with 60 stamps, divided into three units of 20 stamps each. One unit is used for the treatment of ore from the Smuggler mine; the second, that from the Humboldt property and the third receives ore from the Black Bear mine, in Ingram Basin, by means of a wire-rope tramway. Following crushing, and wet concentration on tables and vanners, the ore is treated by oil flotation, which has replaced the cyanide process formerly in use at this plant.

The Smuggler Union Mining Co. was the first in the county to adopt oil flotation. The mill treats between 400 and 500 tons of ore daily, of which about 170 tons is from the Black Bear mine. Bulkeley Wells is president and general manager of the company, Charles N. Bell is general superintendent, and Walter L. Reid is mill superintendent. The Smuggler Union Mining Co. is controlled by the New England Exploration Co., of which Bulkeley Wells is vice president.

Tomboy Gold Mines Company

The Tomboy Gold Mines Co., Ltd., operates two properties—the Argentine and the Montana. These properties are in Savage and Marshall basins at an altitude of about 11,500 ft. The old Tomboy mine, in upper Savage basin, was worked out 10 years ago. The company owns 76 claims. The Tomboy and Montana properties are developed to a depth of 2400 ft., and the Argentine is developed to a depth of 2200 ft. During 1916, 5159 ft. of development work, made up of 4676 ft. of drifting, 467 ft. of raises, and 16 ft. of crosscuts, was performed in the Montana property, which is now opened longitudinally by the Ophir tunnel level. The old Revenue raise was straightened, retimbered, and converted into a shaft for an additional distance of 168 ft. to a point 25 ft. below the 2050-ft. level. This work has developed the vein for 150 ft. below the 1900-ft. level, and added a considerable block of ground to the ore reserves of the mine. On June 30, 1916, the ore reserves were estimated at 575,000 tons, of which 175,000 tons was in the Argentine and 400,000 tons in the Montana property. The reserve in the Montana mine includes 250,000 tons of ore broken in the stopes. The lower levels of the Argentine mine contain large tonnages of ore carrying from 2 to 5% each of lead and zinc, and from 1 to 2% of copper, that will prove a valuable asset when a process can be applied that will effect both a high percentage of recovery and an economic separation of the constituent metals. Numerous tests by different processes have been made, and are still being carried on, with a view to bringing about a successful treatment

of these ores. Some of the tests have given encouraging promises of success.

The mill in Savage basin is equipped with 60 stamps, concentration and cyanide equipment, and has a daily capacity of 400 to 500 tons. During the year ended June 30, 1916, the mill treated 150,488 dry tons of ore, which yielded in bullion $327,519, and concentrate worth $586,092, or an average of $7.14 per ton. The cyanide plant treated 132,200 tons of tailings, recovering therefrom bullion valued at $164,476, at a cost of 90c. a ton, and yielding a net profit of 31½c. per ton of tailings treated. Forty-two per cent. of the value of the yield from the ore was in the form of bullion. The costs amounted to $4.92 per ton. The total revenue for the year ended June 30, 1916, was $1,120,320, and the profit was $369,200, which, with a balance of $99,760, made available $468,960, of which $149,000 was paid in dividends. Total dividends since 1899 amount to over 262%. The concentrating mill and cyanide plant have been built and paid for out of profits, as well as additions and improvements to the plant of the Tomboy Tramway and Tunnel Co., which operates a wire-rope tramway between the Ophir tunnel and a loading station at Pandora, for the outgoing concentrate and the incoming supplies. The company is experimenting with flotation. The Tomboy properties have been under the efficient management of David A. Herron for the last 15 years. P. L. Foster is consulting engineer, and W. K. Betty is metallurgical adviser.

The Liberty Bell Gold Mining Co. operates the Liberty Bell mine, in Cornet basin, north of Telluride. The ore is gold- and silver-bearing quartz in a fissure vein averaging 3 to 4 ft. wide. The main orebody strikes northwest and southeast, and dips 57° to the southwest. The property is developed by a 2600-ft. crosscut tunnel, known as the Stilwell tunnel, and a 1000-ft. raise from the tunnel level to the abandoned upper workings. The ore is mined from open stopes on stulls, and by shrinkage stoping. A 500-ton concentrator and cyanide plant is situated on the railroad about one mile east of Telluride. The ore is transported from mine to mill over a wire-rope gravity tramway 1½ miles long. In 1916 the extraction averaged 88 per cent.

Recent Developments at the Liberty Bell Mine Disclosed Good-Grade Ore

The most important recent development was the driving of a new level about 150 ft. below the level of the tunnel. This demonstrated the continuance of an oreshoot of a good grade of ore, which is about 400 ft. wide. Further sinking and driving are planned, which will probably develop another block of ore. It is a curious coincidence that the center and greatest depth of the oreshoot has been found in the middle of the property and at the place of maximum early developments through tunnel and raise. The levels driven both east and west of this central area showed absence of ore at depth. Late in 1916 a lease was entered into with the Smuggler Union company for the mining of ore in ground of that company adjoining the Liberty Bell property to the east. Development has progressed in this ground with promising results.

During the year ended Sept. 30, 1916, the total receipts were $823,459, or an average of $4.98 per ton milled. Of this sum, $542 was from stamp bullion, $730,272 from cyanide products, and about $60,975 from concentrate. The total operating expenses were $670,-

BULLION TUNNEL, SMUGGLER UNION MINE. VIEW LOOKING WEST ACROSS MARSHALL CREEK

912, or $4.07 per ton milled. The profit was $152,547, or 91c. per ton milled. The production during the past few years was as follows:

PRODUCTION LIBERTY BELL GOLD MINING CO., 1912–1916

Year	Tons Treated	Ounces Silver	Ounces Gold
1912	175,340	313,845	48,993
1913	179,216	288,602	36,693
1914	173,840	315,919	33,150
1915	174,100	314,432	24,054
1916	165,300	256,711	30,580

The reduction in amount of ore handled in 1916 was due to the scarcity of labor during a great part of the year, and to the scattered and irregular nature of the mining. The company has been managed for many years by Charles A. Chase, H. G. McClain being superintendent.

Smaller Producers Are Numerous

The Colorado-Superior Mining Co. owns the Black Bear Mining Co., which holds 30 claims, including the Black Bear mine, in Ingram basin. The total area is about 322 acres. The mine is situated at an altitude of about 12,500 ft. The ore is lead and zinc sulphides containing gold and silver, in a quartz vein 8 to 10 ft. wide. The vein is supposed to be a southeasterly extension of the Argentine vein in the neighboring Tomboy property. The mine is developed to a depth of 1100 ft. by a shaft at a point 500 ft. from the northwest end of the property, and by crosscuts and drifts. The total underground development aggregates about one mile. After several years' idleness the property was reopened in December, 1914. During the early part of 1916 about 1250 ft. of new underground development was performed. The property is equipped with an electric hoist, two compressors, and a 250-ton flotation unit.

Since the reopening of the mine in 1914 the ore has been treated in the Smuggler mill at Pandora, to which it is transported by a wire-rope tramway, and where 20 stamps have been used on Colorado-Superior ore. During 1916, shipments averaged 170 tons daily, and the total ore milled during the year amounted to 48,450 tons, assaying 0.226 oz. gold, 2.49 oz. silver per ton, 3.23% lead, and 5.77% zinc. The ore reserves are estimated at 100,000 tons averaging better than $5 a ton, with 75,000 tons reported blocked out on July 31, 1917. The mining and milling costs average $2.50 a ton, leaving a substantial margin of profit at the present rate of production. The metals produced in 1916 were: 7055 oz. gold; 68,306 oz. silver; 2,354,459 lb. lead; 2,233,536 lb. zinc; and 15,509 lb. copper. The lead concentrate produced averages 1.81 oz. gold, 18.47 oz. silver per ton, 48.88% lead, 4.9% zinc, and 1% copper. The zinc concentrate averages 0.27 oz. gold, 6.95 oz. silver per ton, 6% lead, and 23.96% zinc. During the year about 6548 tons of concentrates was produced. The ratio of concentration was about 7.4 to 1, and the recovery was from 40% for the zinc to 75% for the lead. J. H. Jasberg is president of the company, and Bulkeley Wells is vice president.

In addition to the mines above mentioned, there are numerous smaller properties in the vicinity of Telluride which are in process of development, and several operating companies, whose production is relatively small. The bulk of the district's production is from the three large operating companies.

On account of the situation of most of the important mines in the upper basins at altitudes ranging from 10,500 to 12,500 ft., mining operations are conducted under severe climatic conditions. The snowfall during the winter and early spring is heavy, and the ground is usually covered with snow from about Dec. 1 to the end of June. It is necessary for the mining companies to provide suitable accommodations for their operating forces. Comfortable bunk houses and boarding houses are provided at the important properties. Board and room are furnished at $1 per day. The company usually furnishes bunks and mattresses, but the men must supply their own blankets. In one of the larger boarding houses each room contains two double-deck steel bunks, one man to each deck, making four men in each room. The best food obtainable is furnished at these boarding houses, the company standing a heavy loss in furnishing board at $1 per day. The company deducts $1.50 per month from each man's pay check, as a hospital fee. The larger companies employ their own physicians, who give first-aid treatment for minor injuries and sickness at the mine. Serious cases are sent to the Telluride hospital, where the men receive treatment under the supervision of the company physician.

Scale of Wage at Telluride Mines

The current daily wage scale of the Telluride district is as follows:

Machine men in stopes	$4.50
Machine men in drifts	4.75
Timbermen	4.50
Timbermen helpers	4.00
Shovelers	4.00
Trackmen	4.00
Trammers	4.00
Miscellaneous mine labor	4.00

There is usually no discrimination in the different nationalities employed, but most of the men engaged in the underground work are foreigners, probably the majority being Austrians, Slavs, Greeks, Italians, Swedes, and Finns.

Manganese Exports From Brazil

Exports of manganese ore from Brazil for the last three years were as follows, the figures being taken from a report of the office of Commercial Statistics of the Brazilian Ministry of Finance, and reproduced in the *Bulletin* of the Pan Amercian Union, June, 1918: In 1915, 288,671 metric tons, of which 266,801 tons were shipped to the United States; in 1916, 503,130 metric tons; in 1917, 532,855 metric tons. In the last two years, the total manganese exported was shipped to the United States.

These figures differ from those published in the *Journal* of Jan. 5, 1918, and we believe the latter, which were reported by the American Consul General at Rio de Janeiro, probably do not include shipments from all ports.

The increase in the import of manganese ores since the beginning of the war has been great, the total exportation in 1913 having been little over 120,000 tons.

No Silver Ore Has Been Mined in the United Kingdom since 1907. During 1916 there was a recovery from copper ore of 687 oz., from gold ore 49 oz., from zinc ore 584 oz., and from argentiferous lead ore 85,165 oz., making a total of 86,485 oz. recovered from ores mined in the United Kingdom in that year.

The Roasting of Sulphotelluride Ores For Amalgamating and Cyaniding*

An Important Paper on the Oxidizing Roasting of Cripple Creek Ores—Details Of Practice and Operating Conditions in the Golden Cycle Mill, At Colorado Springs

BY A. L. BLOMFIELD AND J. M. TROTT

THE Golden Cycle Mining and Reduction Co. operates its custom mill at Colorado Springs on Cripple Creek ores exclusively. These ores are straight sulphotellurides, with practically no base metals. After passing through the sampler, the ore goes to storage bins, where beds of 5000 tons are made to insure uniformity in roasting.

CLASSIFICATION OF ORES

For efficiency, it has been found advisable to separate the ores into two classes, according to lime content. Class A contains not more than 2% CaO and comprises about 66% of the ore treated. Class B contains over 2% CaO, and comprises 34% of the ore treated. Typical analyses of both classes are as follows:

ANALYSES SULPHOTELLURIDE ORES, GOLDEN CYCLE MINING AND REDUCTION CO.

	Class A	Class B
Insol.	86.70	75.90
Al_2O_3	2.30	3.40
Fe	3.26	3.48
CaO	1.57	5.12
S	1.79	1.80
MgO	0.21	1.08
Ignition loss	3.20	6.50
Total	99.03	97.28

The beds of each class of ore are made as large as possible with the available ore as it comes in, to avoid changing from one bed to the other oftener than is necessary. Each roaster will handle 50% more of Class A than of Class B, with practically the same results. This necessitates changing the feeds for each new bed, which has a tendency to produce a poor roast and loss of tonnage at each change.

CRUSHING PREPARATORY TO ROASTING

After leaving the storage bins, the ore is crushed in Schmidt "kominuters," or ball mills. Diagonal slotted screens $^9/_{64}$ by ½ in. are used, which give a product as shown in Table I.

Crushing efficiency is increased by coarse crushing in "kominuters," using Chilean mills after roasting. The finer the crushing the greater the dust losses in the roasters. If too fine, there is a tendency for the hot ore to "run" through the roasters. The coarser the crushing the harder it is to roast the occluded sulphides. The ore may appear to be well roasted when too coarse, but, after regrinding, will fill the solutions with soluble sulphides, which increase the consumption of cyanide. The coarse ore itself does not seem to entail a high residue, but the bad effect upon the solution is likely to hinder extraction, unless the plant is extremely flexible. The tendency is toward finer crushing for the more basic ores than for the siliceous. This is roughly adjusted by finer screening before the ore enters the "kominuters" and by using the mills with the newest screens. The average should be not more than 30% coarser than 10 mesh.

The roasting furnaces used are the Edwards Duplex, 54 rabble, supplied by the Stearns-Rogers Manufacturing Co. The length is 115 ft.; width, 13 ft.; line roasting area, 1495 sq.ft.; coolers, 44 ft. long and 14 ft. wide, with an area of 572 sq.ft. There are three fire boxes for each roaster. The temperature of the ore at the discharge point of the roasters is about 485° C.; at the discharge point of the coolers, about 278° C. The temperature depends on tonnage, air temperature, and the rate of rabbling. Trials were made on rabble speeds from 1½ r.p.m. up, and the most efficient cooling was at a rabble speed of 6 revolutions per minute.

The spindles, rabbles and teeth are made of cast iron by a local foundry. The consumption of teeth is 0.1637 lb. per ton of ore; of rabble arms, 0.0684 lb. per ton of ore, and of spindles, 0.0265 lb. per ton of ore.

All rabble arms are water cooled. After passing through the rabbles, the water is run over a cooling tower and pumped back to the storage tank. The temperature of the water going into rabbles is 78 to 93° F., depending upon the temperature of air, the wind, and the tonnage in roasters. Its temperature on leaving the rabbles varies from about 113 to 147° F. The water used per roaster per minute varies from 90 to 115 gal., depending upon the condition of the rabbles and the rate of feed. There are 27 pairs of rabbles in each roaster and 11 pairs in the cooler. In the roaster they travel 3 r.p.m. and in the coolers, 6 r.p.m. The hearth is sloped from feed to discharge end, ½ in. to the foot, which is sufficient to cause the ore to move forward under the action of the revolving rabbles. The greater the rabble speed, the less tendency there is to burn or "ball" the ore under excessive heat. The average time

TABLE I. SCREEN ANALYSIS OF BALL MILL PRODUCT

Size	Old Screens %	Cum. %	New Screens %	Cum. %
Over 5/32 in.	6.1	6.1	1.1	1.1
5/32 + ⅛ in.	5.1	11.2	2.4	3.5
⅛ in. –10 mesh	24.0	35.2	16.6	20.1
10– 20 mesh	22.2	57.4	26.2	46.3
20– 30 mesh	8.0	65.4	10.2	56.5
30– 40 mesh	5.2	70.6	7.6	64.1
40– 60 mesh	6.4	77.0	9.8	73.9
60– 80 mash	1.2	78.2	1.2	75.1
80–100 mesh	2.5	80.7	3.0	78.1
100–150 mesh	2.2	82.9	3.9	82.0
150–200 mesh	4.2	87.1	4.4	86.4
Below 200 mesh	12.9	100.0	13.6	100.0
Total	100.0	....	100.0	....

*Excerpt from paper to be read at the Colorado meeting of the A. I. M. E., September, 1918.

of passage of the ore through the roasters is 6 hours. From 13 to 17 hp. is required for each roaster and cooler, depending on the feed and the speed of the rabbles.

The roasted ore falls from the cooling hearth through a choke feeder onto a 315-ft. reciprocating drag conveyor. The sheet-iron fins are 34 in. long by 8 in. deep. An average of 16½ hp. is required to operate it. The roasters are shut down the first of every month to allow repairs to be made on this drag. The pins that hold the fins are subject to great wear near the discharge end where water is sprayed on the ore before it falls on a rubber conveying belt. This belt is made of specially vulcanized rubber to withstand the heat and moisture. The ore is at about 194° F. when it falls on this belt, and contains 2% moisture. The contained heat serves to warm the building throughout the year. It also, unfortunately, warms the cyanide solution in which the ore is crushed, thus putting large quantities of calcium sulphate into solution.

Coal Used for Roasting

The coal is Colorado Springs lignite, from mines six miles north of the city. The average analysis is as follows: Water, 20.2%; volatiles, 54.65; fixed carbon, 19.75; ash, 5.1; sulphur, 0.30%. Average heating capacity, as mined, 870 B.t.u. For Class A ore, 249 lb. of coal per ton of ore is required for roasting; if for Class B ore, 347 lb. is needed. The firebox requires the use of live steam; 12% additional coal is used to generate this steam. The capacity per roaster ranges for Class A ores from 125 to 150 tons per 24 hours, and for Class B ores, from 80 to 100 tons per 24 hours.

Flue Losses

Extensive stack tests were made in 1909 to determine the flue losses. The method was the use of the Pitot tube for measuring velocities and employing bags for collecting the dust. The volume of flue gases per roaster was 208,000 cu.ft. per min. At the time of the first tests, the revolving cooler was in use, and the stack loss amounted to 13.2c. per ton on 1-oz. ore. After changing to the present coolers, the dust loss was 3 to 4c. per ton of 1-oz. ore. The amount of flue dust collected was formerly from 0.7 to 0.9% by weight and carried a value 32% higher than the ore. It is now 0.4% by weight and carries a value 20% higher than the ore. The open cooler and more careful feeding and discharging had made this difference.

Conditions of Roasting

The temperature, as indicated by Brown indicating pyrometers, is as follows:

Class A ore, 800 to 870° C. in the center of the arch, 8 ft. above No. 1 firebox and in the flow of heat; 800 to 850° C. 8 ft. above No. 2 firebox.

Class B ore, 850 to 900° C. above No. 1 firebox; 850 to 870° C. above No. 2 firebox.

In roasting all ores, No. 3 firebox keeps the ore at a red heat up to the point of discharge. The hotter the ore is kept here, the less tendency there is for the sand of Class B ore to "set" in the leaching tanks. Class A ores show no such tendency within the present treatment conditions. Nevertheless, they will do so under other conditions of classification and filling.

The draft should be kept up to about 0.2 in. of water at all times to allow a free escape of the gases and consequently a more oxidizing atmosphere. The flames from the fireboxes must be given an excess of air to keep them from being smoky, as their reducing effect then is strong.

Chemical Reactions in Roasting

Siliceous Ores—$FeS_2 + \text{heat} = FeS + S$.

$FeS + \text{heat} + O = FeO + SO_2$.

FeO may further oxidize to Fe_2O_3.

$FeSO_4$ is found when roasting at low temperatures, but at high temperatures this decomposes into FeO and SO_3 or $SO_2 + O$.

Basic Ores—In the roasting of calcareous ores containing metallic sulphides, if sufficient sulphur be present the lime is converted almost quantitatively into $CaSO_4$. The behavior of $CaSO_4$ when heated in the presence of CO and C, has been investigated by H. O. Hofman and W. Mostowitsch.[1] The chemical reactions and temperatures stated herein are taken largely from their reports. They are given, as they appear to fit the Class B ores as roasted.

The reduction of $CaSO_4$ by CO is indicated in the equation $CaSO_4 + 4CO = CaS + 4CO_2$. The reaction takes place without any loss of sulphur. Little reaction takes place unless the temperature is above 680° C. Between 750 and 850° C. the action is rapid and is completed at 900° Centigrade.

The reduction of $CaSO_4$ by carbon is indicated in the equations $CaSO_4 + 4C = CaS + 4CO$, and $CaSO_4 + 2C = CaS + 2CO_2$. The action begins fairly well at 700° C. and finishes at 1000° C., proceeding most rapidly between 800 and 900° C. At about 800° C., $CaSO_4 + 2C = CaS + 2CO_2$; above 800° C., $CaSO_4 + 4C = CaS + 4CO$.

It was found that CO acted more readily and effectively than carbon alone, both beginning and finishing at lower temperatures. It is probable that the gases CH_4, C_2H_6, and H would act similarly in the reduction of $CaSO_4$, as they are effective with Na_2SO_4.

CaS, if roasted in pure, dry air, does not all revert to $CaSO_4$, but forms a product of about 76% $CaSO_4$ and 24% CaO, with a loss of approximately 32% S. This loss of S is accounted for by the interaction of $CaSO_4$ and CaS, according to the reaction $3CaSO_4 + CaS = 4CaO + 4SO_2$.

The complete elimination of sulphur at this point is probably prevented by the failure of intimate contact between the CaS and $CaSO_4$ and the formation of CaO between the $CaSO_4$ and CaS. Action between $CaSO_4$ and CaS takes place in a neutral or oxidizing atmosphere, but not in a reducing one.

When heating pure $CaSO_4$ in the presence of oxygen it loses its combined water at 900° C. and begins to decompose at 1250 to 1300° C. In the presence of SiO_2 it starts to decompose and gives off SO_3 at 1000° C. and decomposition is completed at 1250 to 1300° C. The action is shown in the equation $CaSO_4 + SiO_2 = CaSiO_3 + SO_2 + O$. An interesting equation is $CaS + FeSO_4 = CaSO_4 + FeS$. It takes place at a low temperature.

In roasting for cyanide treatment, both sulphates and soluble sulphides are deleterious. Soluble sulphides are

[1] Trans. A.I.M.E., (1910), 41, 763.

active cyanicides, and attack zinc freely. They are active reducing agents, and under certain conditions can completely eliminate all oxygen from the solutions. Though precipitating gold to an appreciable extent only in acid solution, when the solution percolating a charge becomes deoxidized by an excess of soluble sulphide, either gold is precipitated or the undissolved gold is so coated as to render further dissolution so slow that to obtain a low residue is impossible. In agitating slimes, especially without air, a similar condition is brought about.

It is interesting to note that if such a residue is completely dried or thoroughly treated with a solution of permanganate of potash or other effective soluble oxidizer, and then subjected to cyanide treatment, the normal residue is obtained rapidly. Acid sulphates act as virulent cyanicides if not quickly neutralized. Calcium sulphate, formed either in the roasters or by reaction of soluble sulphates in the ore on meeting the lime in solution, is decidedly deleterious. The hot ore warms the crushing solution. This becomes saturated with calcium sulphate and precipitates as the solution cools. These crystals fill pipes, launders and Dorr thickeners, render filter mats and clarifying mats impermeable, coat Merrill filter frames and cloths and form a deposit on the zinc and zinc boxes. In Class A ores these troubles are comparatively unimportant, although considerable time is required to neutralize the solutions, whereas Class B ores often require none.

Formation of Soluble Calcium Sulphate

The chief formation of soluble calcium sulphate, with Class B ores, undoubtedly occurs in the roasters. It will be noted in the roaster equations quoted that, somewhere above 870° C., the final molecule of water is driven out of the calcium sulphate. It then becomes practically insoluble in working solutions and does not form a cement in the sand tanks. For illustration, a ton of deposited calcium sulphate crystals and slime, if fed slowly or rapidly into the Chilean mills, forms a band of cement sand in the leaching vats and redeposits throughout the plant. If, however, 10 tons of this material is fed into the "kominuters" and thence through the roasters, meeting a heat of 870° C. or higher, it cannot be noticed in the cyanide plant.

It is commercially possible to roast ores so that they may be treated with the ease of a free-cyaniding raw ore; this is what is called an "over-roast" at the Golden Cycle mill. Such ore can be extracted to a finished residue in a good standard cyanide plant. Chemical consumption is held at a minimum. Standard classification is sufficient, and no change of solution is necessary. Solution is rapid and reaches a definite end point. But the roast is decidedly more expensive, and the final residue much richer than that now obtained.

Table II shows the value of typical sand residues from Class B ore, first that from an over-roasted ore, and, second, an average sand residue such as is now obtained. The slime residues show even a greater difference in gold content due to over-roasting, the difference being more marked in Class B than in Class A ores.

Having found that a better residue could be obtained by a cheaper and, as indicated by ordinary sulphur analyses, a less complete roast, it was decided to attempt a more efficient treatment by more delicate roasting. This required a quick method of chemical testing and the use of pyrometers to help regulate the temperature of each roaster continuously. Chemical tests were employed for governing the roast. For Class A ores a simple analysis of total, soluble, and insoluble sulphur is a sufficient guide to an experienced fireman, which, with the temperature and appearance of the roaster, soon enables him to regulate his fires. The feed is changed only by the foremen.

TABLE II. VALUE OF SAND RESIDUES FROM CLASS B ORE

	Weight, %	Gold, Oz.	Weight, %	Gold, Oz.
Over 20	...	...	1	0.01
20-- 30	4	0.03	5	0.01
30-- 40	14	0.04	15	0.01
40-- 60	23	0.05	35	0.02
60-- 80	14	0.04	16	0.02
80--100	16	0.05		
100--150	11	0.06	12	0.02
150--200	10	0.09	13	0.02
—200	8	0.12	3	0.04
	100	0.0571	100	0.0185

Total Sulphur in Roasted Ore—Weigh out 1.373 gm. ore, add about 11 drops of a saturated solution of $KClO_3$ in HNO_3, and two or three drops of HCl. Take down to complete dryness to render SiO_2 insoluble, but do not make too hot, or H_2SO_4 will be driven off. Cool, add 5 c.c. HCl, boil off excess, add about 25 c.c. hot H_2O, and boil.

Remove from heat, make alkaline with smallest necessary amount of 1:1 NH_4OH to precipitate iron and leave supernatant liquid clear. Filter and wash twice with hot water. Put filter paper and contents back into same beaker, break filter with 10 to 20 c.c. hot water, and add just enough HCl to dissolve hydrates; put on hot plate a few minutes till solution is effected, then reprecipitate as before with smallest necessary amount of 1:1 NH_4OH, filter and wash into same beaker containing first filtrate. Make filtrate acid with HCl, boil, add a few drops HCl (to prevent boiling over when $BaCl_2$ is added) and then an excess of boiling $BaCl_2$; settle, cool, filter on best double filter paper, wash twice with water, once with 1:1 HCl, then 10 times with water; ignite, and weigh $BaSO_4$.

HCl-Soluble Sulphur in Roasted Ore—Weigh out 1.373 gm. ore, add about 30 c.c. N/10 HCl solution, boil 10 min., filter, and wash well with hot water. Refilter through new double paper and wash well. Boil, add a few drops HCl and an excess hot $BaCl_2$ solution. Settle, cool, filter on double paper, wash, ignite, and weigh. The insoluble sulphur is obtained by difference.

Na_2CO_3-Soluble Sulphur in Roasted Ore—This is run as a check on the HCl method. It gives an insoluble sulphur that is usually about 0.03% higher than the HCl, the notable exceptions being a bad roast on a lime bed, when it may go 0.05 or 0.06% higher.

Weigh 1.373 gm. ore, boil 10 min. with 30 c.c. N/Na_2CO_3 solution, filter and wash well with hot water. Add about 4 c.c. HCl to filtrate, or till acid, boil out CO_2, make just alkaline with a few drops of 1:1 NH_4OH and boil out NH_3. Filter and wash with hot H_2O, acidify filtrate with HCl, boil, add a few drops HCl and an excess of hot $BaCl_2$ solution, settle, cool, filter on double paper, wash, ignite, and weigh.

Class B ores cannot be roasted correctly even approximately by reliance upon visual judgment. The same soluble and insoluble sulphur analyses must be made, but these do not distinguish between the soluble $CaSO_4$ and CaS, the first of which is harmful principally in setting the sand tanks, whereas the second interferes greatly with the extraction.

The usual analyses, therefore, combined with the custom of getting only one report a day, proved too slow to prevent bad roasts, and it was found advisable to develop a quick reliable test for soluble sulphides, by

means of which a check could be kept on each individual roaster. Arlo C. Greenawalt was detailed to devote his entire time to developing a method. After trial of all available text-book methods, he decided upon the following as the best practical method:

Rapid Determination of Soluble Sulphides—Weigh 15 gm. roasted ore crushed through 80 mesh into a 150-c.c. casserole. Pour onto it 50 c.c. boiling 5-lb. KCN solution, containing 12 lb. NaOH per ton (0.6%). Boil for 15 min., then filter by aid of a vacuum into a 100-c.c. graduated cylinder. Wash well with hot water and bring volume of filtrate up to 50 c.c. Mix contents thoroughly by inverting the cylinder several times. Extract two samples of 10 c.c. each. To one sample add an excess of $KAg(CN)_2$ solution and about 1 gm. dry CaO. To the second sample add about 2 gm. dry $PbCO_3$. Heat solutions to boiling, filter and wash well with hot H_2O. Add ½ c.c. of 1% KI solution to each filtrate, and titrate with $AgNO_3$ (13.038 gm. per liter). Subtract the amount of $AgNO_3$ used with the solution to which $PbCO_3$ was added, from the amount used with the solution to which $KAg(CN)_2$ was added. To obtain percentage of soluble sulphides, multiply this difference by 0.16415.

Explanations and Precautions

The above method is based on the fact that when $KAg(CN)_2$ is added to a solution containing alkaline sulphides, a definite amount of free KCN is formed for every atom of silver that combines with the soluble sulphur to form Ag_2S, the equation being $2KAg(CN)_2 + K_2S = Ag_2S + 4KCN$. It is necessary that the solution of KCN be boiling before adding to the ore, as oxidation of the sulphides will take place in a cold solution. NaOH is added to make the solution alkaline, as results cannot be obtained in acid solution. A weak KCN solution should be used, as it will take the sulphides into solution readily, and will require a minimum amount of $AgNO_3$ for titration. When $KAg(CN)_2$ is added to the solution, the precipitation of Ag_2S is usually incomplete and the precipitate seems to be partly colloidal. The CaO is added to coagulate the precipitate, and boiling insures complete precipitation. The wash water should be hot in order to prevent oxidation of the sulphides to sulphates, which occurs if solutions are allowed to cool. The addition of KI before titration corrects errors due to the presence of caustic alkalies.

Titration of solution to which $PbCO_3$ was added gives the original cyanide present. Titration of solution to which $KAg(CN)_2$ was added gives the original cyanide plus the free cyanide that was formed. The difference between the two, or the free cyanide, is directly proportional to the amount of soluble sulphides present in the solution.

The calculation of the value of 1 c.c. $AgNO_3$ (13.038 gm. per liter), in terms of percentage of soluble sulphides, is as follows:

KCN = 65.11. KCNS = 97.18. S = 32.07.

1 c.c. $AgNO_3$ = 0.01 gm. KCN.

$65.11 \div 97.18 = 0.01 \div x$.

$x = 0.01492$ gm. KCNS per c.c. $AgNO_3$.

$32.07 \div 97.18 = x \div 0.01492$.

$x = 0.004924$ gm. sulphur per c.c. $AgNO_3$.

$$\frac{0.004924 \times 100}{15} = 0.03283 = \text{per cent. sulphides.}$$

With 15 gm. ore taken for analysis, $0.03283 \times 5 = 0.16415$ = % soluble sulphides per c.c. of $AgNO_3$, as titration took place in 10 c.c. and the total volume was 50 cubic centimeters.

If the volume should happen to be larger than 50 c.c., say 57 c.c., the factor is obtained thus: $5.7 \times 0.3283 = 0.16696$ = % soluble sulphides per c.c. $AgNO_3$. This method can be run through with nine roaster samples in about 1½ hours, and, though not absolutely accurate, is the best developed at the Golden Cycle mill and is sufficient for controlling the feeds to the roasters, when the temperatures as noted above are maintained. The limits of insoluble sulphur are: Class A, 0.10%; Class B, 0.15%. The limits of soluble sulphide are: Class A, 0.10%; Class B, 0.15 per cent.

Experience has shown that Class B ores give good residues, with higher total and insoluble sulphur and soluble sulphide than those of Class A. The chemical reasons for this are still obscure, but it is possible that the interaction between the sulphates and sulphides in the roasters, as noted, gives a larger amount of each as a secondary reaction, and these then do not have so deleterious an effect in the treatment.

Operating Conditions in the Cyanide Plant

The decision to adopt the more efficient and more delicate treatment already mentioned necessitated a more carefully planned and flexible cyanide plant, specially arranged to cope with the ore thus roasted. The following are the more important operating factors:

1. Substitution of blanket concentration of gold for plate amalgamation.
2. Elimination of colloids, so far as possible, from that part of the ore to be leached.
3. Ability to change solutions quickly on both sands and slimes.
4. Filling the leaching tanks with a semi-dewatered product.
5. Aëration of slimes soon after classification.
6. More time of agitation.
7. Use of the Crowe vacuum system of precipitation.

1. Amalgamation plates are decidedly more sensitive to unfinished roasting than in cyanide solution. The coarse gold is coated with an alloy which dissolves slowly and is not wetted by quicksilver. Blankets catch this gold effectively, and the particles amalgamate readily when the surface is abraded. The amalgamation treatment includes a small arrastra, followed by a grinding pan with universal joint between yoke and muller, and followed by another arrastra. The tails are reblanketed before passing into the main mill flow, and the final concentrate is amalgamated in a barrel in strong cyanide solution.

2. The elimination of colloids from the sands is perhaps the most important detail of all. Unless the sands leach exceedingly fast, a "slip-up" in one roaster will cause the complete deoxidation of solution before it reaches the filter bottom, causing a rich residue. If the leaching charges channel perceptibly, the same condition develops in patches. Moreover, in the Class B ores there is a marked tendency for the sands to set while leaching. Freedom from colloids distinctly minimizes such tendency. It was not until 1915 that the more basic ores began to arrive in large quantities and changes in treatment became imperative. There was no available floor space for step classification, and the clumsiness and the expense of a series of cones and pumps were not attractive. The problem was solved by the installation of the Dorr bowl classifier, which makes a separation as efficient, on this class of work,

as any ordinary three-stage classification, uses less floor space than was necessary before, requires the minimum of attention, additional solution, and power, and its cost for installation and operation are less. Golden Cycle plant requirements are: For the slime plant, all material must pass through 100 mesh and not over 12% remain on 200. For the leaching plant, the sands must be free from colloids. Between these limits, the feed to the classifiers may vary from the product of two Chilean mills—400 tons of ore—to six Chilean mills—1200 tons—without any classifier adjustments. This is useful, as power peak is controlled at the Chilean mills.

3. Change of solution must be made quickly to allow a good margin between an over-roast and an under-roast. On the sands, it is done by the back flow or wash solution in the classifiers. The slimes flow to a 50-ft. connected-type Dorr tray thickener. The compartments are shallow and the settling capacity is always ample. Under these conditions, the slime is quickly passed through as thickened product. This thickener practically clears itself of slime in half an hour after the feed is shut off. The pulp then goes to a mechanical agitator containing perforated air pipes, where the first change of solution is made. A further change of solution and partial decantation are made in tray thickeners of the open type. The pulp then passes to agitators.

4. To fill sand tanks by methods such as Butters' distributors, though mechanically cheaper than the present practice, has the chemical disadvantage of allowing the sand to rest too long in a dead solution in the early stages of treatment. It might be possible to overcome this, as the sand has been cleaned, by opening the valves and draining the solution off and back to the crushing plant. The possible saving in cost of operation over the present semi-dry method of belt conveyor and distributor is small, and the method is not so safe from a chemical standpoint.

5. Aëration of slimes immediately after classification is effective—probably such aëration almost instantly gets rid of the unstable soluble sulphides. At the Golden Cycle mill, the endeavor is to do it fairly fast without additional agitation storage. Possibly, if room permitted, an aërating agitator between classifiers and first settler would be more effective.

6. It is found that a roast giving the lowest residue also gives a slow-treating slime. Therefore excessive agitation is a good safety insurance, and the additional agitation is obtained in a 37 x 23-ft. Dorr agitator, at a cost of 4 mills per ton.

7. The precipitation of solutions from moderately roasted ores, especially of the more basic type, has been distinctly difficult. A marked improvement in effectiveness and cost has been made by the installation of the Crowe vacuum treatment of solutions.

There is room for argument regarding the relative efficiency of treating roasted ores in an all-sliming cyanide plant, or in a combination slime and leaching plant. The all-sliming plant is probably less costly to install, and it reduces the number of metallurgical problems. The Cripple Creek ore, however, after roasting, does not require finer grinding than 20 mesh. Further grinding, even in normal times, costs more than is warranted by the extra recovery attained. The slimes from a roasted ore have small adhesive qualities and are incapable of sustaining much sand. This limits the type of cyanide apparatus available, unless the all-sliming process is carried far beyond the economical crushing limit. Undoubtedly, under local conditions, the residues can be dumped far more economically from a combination slime and leaching plant than from an all-slime process.

The ore is high grade and requires a high-strength cyanide solution, thus limiting the effectiveness of the countercurrent decantation system, although this system is partly used with good effect in the present slime plant, both as a help in extraction and in washing the gold from the filter cakes. If the sands are sufficiently eliminated from the slime product, the latter is an ideal filtering material; but, even so, the filter department is more expensive to operate, requires more care and more wash solution per ton of ore, and loses more cyanide and gold mechanically than the sand plant. The deciding feature between the two types of plant lies in the possibility of consistent efficient classification. With poor classification, the advantages lie with the all-sliming process. With good classification, the balance swings decidedly to the combination plant.

Dividends by Colorado Mines

During the last 10½ years, that is, from Jan. 1, 1908, to June 30, 1918, inclusive, the total disbursements by Colorado mining companies which make public reports amounted to $73,007,006. This does not include the American Smelting and Refining Co., which has large interests in Colorado.

The accompanying table gives payments by companies. In addition it may be noted that the companies on the list paid $5,167,606 in 1916; $4,586,532 in 1917; and $1,546,666 in the first six months of 1918.

COLORADO MINING DIVIDENDS, JAN. 1, 1908, TO JUNE 30, 1918

Company	Total to End of 1917	Latest Dividend Date	Amount
Acacia, g	$122,004	Jan., 1911	$0.00½
Adams, s.l.c	778,000	Dec., '09	.04
Bonanza Dev. g	1,425,000	Oct., '11	.20
Camp Bird, g.s	9,185,498	Nov., '15	.24
Camp Bird, pfd	1,497,655	Jan., '18	.18
Colo. Gold Dredging	775,000	Feb., '16	1.00
Cresson Cons., g	6,539,162	June, '18	.10
Derry Ranch, g	100,000	Oct., '17	5.00
Dr. Jack Pot, g	141,698	Jan., '17	.01
Dunkin, g	55,000	Aug., '16	.07½
Elkton Con., g	3,579,465	May, '15	.02
El Paso, g	1,707,545	Feb., '14	.10
Farncomb Hill Gold Dredg	48,000	Oct., '17	.07
Free Coinage, g	180,000	Dec., '09	1.00
Gold Coin of Victor, g	1,350,000	Feb., '09	.02
Gold Dollar Con., g	100,000	Dec., '12	.00½
Gold Sovereign, g	32,560	Nov., '12	.00½
Golden Cycle, g	8,448,500	June, '18	.03
Granite, g	352,500	Jan., '18	.02
Iowa, g.s.l	336,833	July, '17	.01½
Iowa-Tiger, g.s.l	25,179	Dec., '15	1.00
Iron Silver, s.l.g	5,250,000	Dec., '17	.10
Isabella Mines, g.s	742,500	Dec., '16	.01
Jerry Johnson, g	187,500	Nov., '14	.00½
Liberty Bell, g	2,193,513	Sept., '17	.03
Mary McKinney, g	1,182,398	Oct., '16	.01
Mary Murphy, g	93,106	May, '16	.07
Monarch-Madonna, g.s.l	40,000	Apr., '11	.01
Modoc, g.s	275,000	Dec., '11	.01
Pharmacist, g	87,500	Feb., '10	.01½
Portland, g	12,137,080	Apr., '18	.03
Rico-Wellington, l.z.c	39,600	July, '17	.....
Tomboy, g.s	4,126,140	June, '18	.12
United (Crip. Ck.), g	520,385	Dec., '17	.01
Valley View, g	240,000	Dec., '11	.04
Vindicator Con., g	3,712,500	Oct., '17	.03
Wellington, g	1,850,000	May, '18	.10
Work, g	172,500	July, '08	.00½
Yak, s.l	3,477,685	Sept., '17	.07

Among the companies not represented because the details are unknown are Stratton's Independence, now being wound up, which has paid dividends of about 85%, and the Gold King Gold Mining Co., a close corporation, which has probably paid about $1,500,000.

The Manufacture of Ferroalloys In Colorado

Excerpt From a Paper To Be Presented at the Colorado Meeting of the American Institute of Mining Engineers—Details of Ferroalloy Plants and Methods of Manufacture

By ROBERT M. KEENEY

BEFORE the outbreak of the war in 1914, the only electric-furnace smelting plant operating on a commercial basis west of the Mississippi River was an electric pig-iron plant in California. Rare-metal ores were not smelted, concentrates of molybdenum, tungsten, uranium and vanadium ores being shipped East for reduction. Practically no chrome ore was being mined, and only comparatively small amounts of manganese ore. Today there are two electric-smelting plants in California, one in Washington, one in Iowa, and four in Colorado; two plants are under construction in California, and one in Montana. Ores of manganese, chromium, molybdenum and tungsten are now smelted in the West, and although uranium and vanadium concentrates are still shipped to the East, they will probably soon be treated in Western plants. The four electric-furnace plants in Colorado are listed in Table I.

TABLE I—ELECTRIC-SMELTING PLANTS IN COLORADO

Company	Location	Capacity, Kilowatts	Products
Tungsten Products Co.....	Boulder	800	Ferrotungsten, ferromolybdenum.
Boulder Tungsten Production Co.....	Boulder	400	Ferrotungsten.
Ferro Alloy Co.....	Utah Junction	1200	Ferrochrome, ferrotungsten.
Iron Mountain Alloy Co.....	Utah Junction	3000	Ferromanganese.

Power for all of these plants is supplied by the Colorado Power Company.

Ferro Alloy Company's Plant

The plant of the Ferro Alloy Co., at Utah Junction, contains one 750-kw., three-phase furnace, to which power is supplied by three 250-kw. transformers, connected Δ/γ to give 129 volts on the furnace cables, the transformer ratio being 13,200 to 75 volts. The furnace operates with an actual voltage of 120 volts, and produces about three tons of ferrochrome per 24 hours from 40% Cr_2O_3 ore. The furnace consists of a steel shell of circular cross-section, 8 ft. in diameter by 7 ft. deep, lined with magnesite, and having three vertical carbon electrodes 12 in. in diameter.

A 450-kw. furnace, of the same size as the 750-kw. furnace, is also operated on chrome ore. This furnace is three-phase in appearance, but operates electrically as a single-phase furnace. There are three vertical carbon electrodes 8 in. in diameter with a conducting carbon bottom. Power is supplied by three 150-kw., single-phase transformers, two of which have a ratio of 13,200 to 95 volts, and one having a ratio of 13,200 to 100 volts. From each transformer, one lead goes to one vertical electrode, and one lead to the carbon bottom, so that the transformers are electrically independent. The furnace voltage varies from 90 to 95.

At intervals, 150-kw., single-phase furnaces are operated on ferrotungsten. These furnaces have one vertical graphite electrode 4 in. in diameter, with a water-cooled steel bottom contact. The furnace shells are 4 ft. in diameter, and are mounted on trunnions, the slag being poured by tilting the furnace. All of the electrodes are regulated by hand. The chrome furnaces are operated without roofs and the tungsten furnaces with roofs. The whole plant has a power factor of 90 per cent.

Iron Mountain Alloy Company's Plant

The plant of the Iron Mountain Alloy Co., at Utah Junction, contains one 1200-kw. three-phase furnace, and one 1800-kw. three-phase furnace, giving a total capacity of 12 long tons of ferromanganese per 24 hours. The 1200-kw. furnace is supplied with power by three 400-kw., single-phase transformers, having a ratio of 13,200 to 75 volts, and connected Δ/Δ. The pressure on the furnace is 72 volts. The 1800-kw. furnace is connected to three 600-kw. single-phase transformers having a ratio of 13,200 to 75 volts, and connected Δ/Δ. The power factor of the plant is 85%. The furnace shells in both cases are 18 ft. long, 8 ft. wide, 7 ft. deep, and are lined with magnesite. The electrodes on the smaller furnace are of carbon, 17 in. in diameter, and on the large furnace 24 in. in diameter; in both furnaces they are threaded for continuous feeding. No roofs are used, and regulation of electrodes is by hand.

Ferrochrome

The process of making ferrochrome from domestic chromite ore consists of mixing ore, coal or coke, lime, fluorspar, or silica, in proper proportions, and smelting this mixture in an electric furnace. At 2-hour intervals the ferrochrome and slag are tapped into iron pots, the metal settling to the bottom. The pot is dumped when the contents are solidified. Reduction theoretically takes place according to the reaction:

$$FeO.Cr_2O_3 + 4C = Fe.2Cr + 4CO$$
$$9FeO.9Cr_2O_3 + 50C = [2(Fe_3C.3Cr_3C_2) + 3Fe] + 36CO$$

Domestic Chrome Ores

In smelting domestic ore, which has a higher percentage of slag-forming constituents than foreign ore, and averages 40 to 45% Cr_2O_3, considerably higher loss of chromium occurs, and it is more difficult to control the carbon content of the product. By permitting a higher slag loss, the carbon can be kept below 6%, but varies between 4.5 and 8%. The products are sorted into ferrochrome with 6, 7 and 8% carbon; the greatest demand is for the 6% carbon product, but large quantities of the other grades are used by the steel industry. The iron content of domestic ores is higher than that of foreign ores, with the result that the chromium content of the product varies from 60 to

65%, instead of 65 to 70%. In smelting chrome ore to produce a ferrochrome with 8% carbon, considerably higher recovery can be attained than when making a 6% carbon product, for two reasons: (1) excess of carbon permissible in the charge; (2) when it is not necessary to limit the carbon to 6%, fluxing materials can be charged, giving a more fluid slag and resulting in better separation of slag from metal. There is no difficulty in obtaining a recovery of 90 to 95% of the chromium when making 8% carbon product, whereas the recovery on the 6% carbon grade varies from 70 to 80%. Within limits, the grade of ore smelted has no appreciable effect on the recovery when 8% carbon product is being made.

On the whole, when producing ferrochrome with 6% carbon, a small quantity of silica and lime make the most satisfactory flux, if any flux is necessary. The recovery is a little higher than where running with a natural slag, and the presence of silica in slight excess tends to throw carbon and sulphur out of the alloy. Ferrochrome sometimes contains over 2% silicon when sand is charged, but this is not objectionable.

When making 8% carbon product, the slags average 5.21% chromium, as against 13.13% chromium when producing 6% carbon material, a difference of 7.92%. The chromium recovery on ferrochrome of 8% carbon is 94.07%, in comparison with 74.15% when producing material containing 6% carbon, or 19.92% higher recovery.

Ferrochrome containing 6% carbon can be made easily by using a natural slag. The chromium content of such slag is 8.56%, whereas, when using lime and silica, the slag contained 13.13%, and with silica alone as a flux it varied from 17.5 to 26.6% chromic oxide (12 to 18.2% chromium). In the three cases, the actual chromium tapped was respectively 73.0, 74.15 and 71.02%. The combination of lime and silica thus shows a little higher recovery. Generally, however, if the slag will run, it is advisable to use a natural slag. When the alumina is about 35% and the silica 20 to 25%, these slags are exceedingly fluid, but at times retain metallics. The use of a large quantity of silica does not improve the recovery, but it does have a marked effect on the sulphur content of the alloy.

There has been much discussion as to how low-grade chrome ore can be used in the manufacture of ferrochrome. In smelting chrome slag containing from 13.9 to 36.25% Cr_2O_3, an average recovery of 80.2% was made, with the production of metal containing an average of 61.34% chromium, 6.81% carbon, 0.063% sulphur, and 2.5% silicon. Even with a very low-grade slag, 15% Cr_2O_3, a recovery of 85% was made. The cost of actual operation was not much greater than when smelting ore, but, including interest and depreciation charges, the total cost would be considerably higher, because of the small output of metal for the power consumed. From these results, it seems reasonable to expect that a good recovery could be made from ore containing 25% Cr_2O_3 if the product were allowed to contain 7% carbon. Ferrochrome made from domestic chrome ore ranges from 60 to 67% chromium, as compared with 65 to 70% chromium in ferrochrome made from imported ore.

Tungsten is the leading alloy metal used in the manufacture of high-speed steel. Probably about half of the consumption is used in the form of ferrotungsten, the remainder being tungsten metal. Colorado has supplied a large part of the tungsten used in steel manufacture, but is gradually being surpassed by California, where the large scheelite deposits can produce tungsten considerably cheaper. Ferberite, found in Boulder County, Colo., is one of the most favorable forms of tungsten for production of ferrotungsten, containing both iron and tungsten in the proper proportion to yield 70 to 80% ferrotungsten. At present, three electric-furnace plants in Colorado are making or have made ferrotungsten. The standard grade produced by the Ferro Alloy Co. contains 75% tungsten, 0.8 carbon, 0.4 silicon, 0.5 manganese, 0.01 sulphur and 0.02% phosphorus. The Tungsten Products Co. makes about the same grade of product, except that the carbon is kept below 0.5%, and the tungsten runs as high as 85%. The product of this company is probably the highest grade and the purest ferrotungsten made in this country. Ferrotungsten has a high density, fine gray fracture, and is not crystalline—the higher the carbon the coarser the fracture. The carbon in ferrotungsten occurs as the double carbide, $Fe_3C.W_2C$.

One method commonly employed for production of ferrotungsten is reduction of ferberite or some other concentrate in the electric furnace, with carbon as a reducing agent, followed by a subsequent refining and decarburization. Reduction with carbon takes place according to the following reaction:

$$Fe_2WO_4 + 4C = Fe_2W + 4CO.$$

Theoretically, the product would contain 62.3% tungsten, but, owing to the variation in iron in the ferberite, and to the fact that tungsten reduces from ferberite in the electric furnace before the iron comes down, a considerable part of the iron passes into the slag, so that the alloy contains about 70% tungsten. The slag may contain as high as 8% FeO, but less than 1% WO_3. Theoretically, the reduction of 100 parts of alloy from 122 parts of ferberite requires 16 parts of carbon, but practically about 25% excess of carbon is charged. Small amounts of lime and fluorspar are used to flux the silica. Operating in this manner, with an excess of carbon, a product is made containing 3% carbon, 70% tungsten, 0.05% phosphorus, and 0.01% sulphur; the slag contains below 1% WO_3. If desired, this product can be tapped from the furnace, but, as its behavior is erratic, it is preferable to allow the metal to collect in the bottom of the furnace, forming, in a 150-kw. furnace, a button about 3 ft. in diameter, 6 in. thick, and weighing 1000 to 1200 lb.; the slag is poured off by tilting as it fills the furnace.

Smelting of Ferberite Concentrate

A typical operation is conducted as follows: The initial charge is 65 lb. of a mixture composed of 200 lb. concentrate, 42 lb. coke, 56 lb. lime, 6 lb. fluorspar. Three more 65 lb. charges are added at intervals of ½ hour, and, at 2½ hours from the start, the furnace is tilted and the slag poured. This cycle is repeated until a 1200-lb. button has been formed, requiring 24 to 36 hours. The furnace is allowed to cool, is torn down, and the button of metal removed. This is then cleaned and broken up, the breaking process being somewhat difficult with a 3% carbon alloy.

The slags produced average 0.72% tungsten, and

though there is considerable mechanical loss, due principally to dusting, the total loss in practice does not exceed 5 per cent.

Refining Ferrotungsten

The crude metal, broken to about 6-in. size, is refined as follows: A charge of 150 lb. metal and 75 lb. ferberite concentrate is smelted for ½ hour, when 12 lb. of fluorspar is added. After another 3 hours the slag is poured, and a fresh charge is started. The process is continued for from 36 to 48 hours, until a button weighing 1500 lb. has formed in the furnace, a larger button being permissible because the low-carbon alloy is easier to break. The furnace is allowed to cool, is torn down, and the button of metal removed, cleaned, and broken. The refined button forms compactly and is free from slag. The refining reduces the carbon from 3 to 0.8%, the phosphorus from 0.05 to 0.01%, leaves the sulphur the same, and increases the tungsten from 70 to 75%. The refining slag contains 5 to 20% tungsten, and is resmelted in a special run.

Ferrotungsten is one of the easiest ferroalloys to manufacture, except for the fact that it must be made in a knock-down furnace, due to the high melting point of the alloy, about 2500° C. Metallurgically it is simple, as tungsten has not so great a tendency to form carbides or to oxidize as have chromium and uranium. Ferrotungsten containing less than 1% carbon can be made in a single smelting operation, by careful regulation of the carbon in the charge and the use of an acid slag. The disadvantage of this method is that the product is less pure, and the slag loss is considerably higher. The metal will contain much higher phosphorus and sulphur, and the total loss of tungsten may be 25%, as compared with 10 to 15% by the two-stage process.

Nearly every manufacturer of ferrotungsten has tried to tap it from the furnace, but none has continued the practice. If the tungsten is reduced to 55 to 60%, the alloy can be tapped, even with carbon as low as 0.2%. With tungsten at 70%, metal containing 0.9% carbon has run out while pouring slag, but generally any metal which comes out with the slag will contain 1.25% carbon. The irregularity of tapping operations with ferrotungsten has prevented the adoption of that method, because if part of the metal must be retained in the furnace, it is cheaper to keep it all there. Furthermore, the poured metal is very hard to break.

In ferrotungsten production it is essential to maintain regularity of charging, as this is the only way to insure homogeneous composition of the metal, as the button is not melted throughout. Even during refining, the metal does not melt to any extent, the action taking place while the metal is in a pasty condition. To insure a more homogeneous product, consumers require the alloy to be crushed to ¼ in., this crushing forming one of the main trials of the manufacturer.

FERROTUNGSTEN ANALYSES

Tungsten %	69.7 to 74.19
Carbon, %	0.88 to 1.00
Silicon %	0.39 to 0.76
Manganese %	0.15 to 0.53
Sulphur %	0.002 to 0.055
Phosphorus %	0.013 to 0.037

Analyses of ferrotungsten made from ferberite by smelting and refining indicate the limits in composition shown in the table.

All vanadium ores require a chemical treatment to put the vanadium in the form of vanadium oxide or iron vanadate before it can be reduced to metal. Probably 75% of the ferrovanadium produced is made in the openhearth or crucible furnace, by a modification of the Thermit process, using aluminum as a reducing agent. The remainder is produced by the electric furnace, using 90% silicon metal as reducing agent.

Standard ferrovanadium contains from 30 to 40% vanadium, and less than 0.5% carbon, 1% silicon, 2% aluminum, 0.1% sulphur, and 0.1% phosphorus. It has a fine fracture, is not crystalline, and is bright gray in color. Experience has shown that the 33% grade is best for making vanadium additions to steel. Carbon is objectionable in ferrovanadium, because over 1% carbon causes some of the vanadium to enter the steel in the form of carbide, producing an injurious effect.

The largest output of ferrovanadium is made by reduction of vanadium oxide or iron vanadate with aluminum shot in a gas-fired openhearth, slagging off the alumina by addition of soda ash or fluorspar. If vanadium oxide is used, iron turnings are added as necessary. The process is partly exothermic, but not enough heat is produced by the reaction between the aluminum and the vanadium oxide to carry on the reduction without the application of heat. The use of iron vanadate is open to the objection that additional aluminum is required for the reduction of iron, which increases operating costs considerably at present. Reduction takes place according to the reaction:

$$3V_2O_5 + 10Al = 6V + 5Al_2O_3$$

In the electric-furnace process, the use of carbon as reducing agent for vanadium oxide has been generally discontinued because of the difficulty in keeping the carbon low, and the tendency to form carbides, which the steel manufacturers maintain are injurious to steel. Silicon has been found the best reducing agent, aluminum volatilizing too easily and being more expensive. The raw materials for the manufacture of ferrovanadium in the electric furnace are steel turnings, vanadium oxide, silicon, lime, and fluorspar. The turnings should be low in carbon. Though 90% silicon metal, ground to 60 mesh, is preferable, ferrosilicon can be used if necessary. All of these materials should be low in phosphorus. Any standard type of electric furnace can be used for making ferrovanadium, but it should be lined with magnesite.

The steel turnings are first charged into the furnace; when they are melted, vanadium oxide is added, followed by a mixture of silicon and lime. When the slag is fluid, in from 1 to 1½ hours, it is raked off, and more vanadium oxide charged, followed by a mixture of silicon and lime. About an hour after this the slag is pulled out and the metal tapped. Instead of pulling the slag out through a door, a separate slag tap hole may be provided. A large quantity of slag is formed in the operation, because of the large quantity of lime which must be charged to combine with the silica formed by reduction of vanadium oxide with silicon. If iron vanadate is used instead of vanadium oxide, no turnings are charged, and the quantity of silicon and lime is increased. This operation is based upon the following reactions:

$$2V_2O_5 + 5Si = 4V + 5SiO_2$$
$$5SiO_2 + 5CaO = 5CaSiO_3$$

The ferrovanadium produced in this manner contains from 4 to 8% silicon, 30% vanadium, 0.5% carbon, 0.05% sulphur, 0.05% phosphorus. A product containing 2 to 4 % silicon can be obtained in a single operation by reducing the amount of silicon charged, and allowing a greater loss of vanadium in the slags. The slags from normal operation contain less than 1% vanadium.

In electrical smelting of vanadium oxide there is an average recovery of 75.2% of the vanadium, with a power consumption of 2.1 kw.-hr. per lb. of ferrovanadium. Smelting of iron vanadate shows similar results, except that there is a considerably greater consumption of silicon metal, owing to the necessary reduction of iron oxide.

Refining Ferrovanadium

To obtain a ferrovanadium containing less than 1% silicon, the 4 to 8% product from the smelting furnace is refined in the electric furnace with a slag of vanadium oxide, lime, and fluorspar, giving a product containing 35% vanadium, 0.9% silicon, 0.5% carbon, 0.05% sulphur and 0.05% phosphorus. In the refining process, the ferrovanadium is simply mixed with the slag-forming materials in proper proportions, melted in the furnace, and tapped. The removal of silicon in this manner is a simple matter, and much less difficult than refining to remove carbon. The silicon in the ferrovanadium reduces the vanadium from the oxide, and passes off as calcium silicate in the presence of lime. The usual grade of vanadium oxide contains over 80% V_2O_5. Iron vanadate contains from 25 to 40% V_2O_5. Slag produced by refining contains about 5% V_2O_5, and is run back through the refining furnace so that there is no loss of vanadium by this method. Also, there is no danger of reducing the high silica in this slag, as it cannot be reduced when silicon is the only reducing agent present.

The power consumption for refining was 1.7 kw.-hr. per lb. of ferrovanadium produced, which, added to 2.1 kw.-hr. for smelting, gives a total of 3.8 kw.-hr. per lb. of refined ferrovanadium. The increase in grade of the ferrovanadium from 35.8 to 37.0% is due to the replacement of silicon by vanadium during refining. The carbon of the ferrovanadium could be reduced from 1.5% to less than 1%, but a considerable quantity of the vanadium originally present in the alloy oxidized and went into the slag. Also, it was difficult to get clean taps, as the metal did not separate readily from the slag.

Ferromanganese

The preparation of ferromanganese in the electric furnace consists in charging a proper mixture of ore, coal, and limestone in correct proportions for the reduction of manganese with a minimum slag loss. The furnace operates at 75 to 100 volts. With dioxide ores reduction takes place according to the reaction:

$$MnO_2 + 2C = Mn + 2CO$$

Iron is added either as a constituent of the ore or in the form of iron turnings. The power consumption varies from 4000 kw.-hr. per long ton in a 3000-kw. furnace to 7000 kw.-hr. per long ton in a 1000-kw. furnace. The electrode consumption is high, ranging from 150 to 250 lb. per long ton of product, when using amorphous carbon electrodes.

Smelting an ore averaging 38.9% manganese and 13.0% SiO_2, the recovery in metal tapped is 75.4%, with an average loss of 17.3% in the slag and 7.3% mechanically and by volatilization. Considerably better results are now being obtained, especially as regards slag loss. The power consumption was 6429 kw.-hr. per long ton of ferromanganese, measured on the primary side of the transformers. The average metal produced contained manganese, 79.34%; silicon, 1,2; phosphorus, 0.202; sulphur, 0.018%. The quantity of coal charged was less than 10% above the theoretical amount required for complete reduction, which is contrary to the practice at several electric-furnace plants.

Ferromolybdenum

The use of ferromolybdenum in the metallurgy of steel is in its infancy. Previous to 1914, probably not over 10 tons was produced yearly in the United States, practically all of this being exported; but with the high price of tungsten, search for molybdenum ores became more active, and now several hundred tons of the alloy per year are made here, practically all of which is exported. The alloy has not been widely used, because of the supposed scarcity of ore and the prejudices of American steel manufacturers against it, owing to difficulties encountered in its use in steel. The scarcity of ore has been overcome, and at present Colorado is the largest producer of molybdenum in the world. The prejudices of American steel manufacturers have not, however, been surmounted.

Ferromolybdenum was made from roasted molybdenite in the crucible before the introduction of the electric furnace, but can now be made directly from raw sulphide in the electric furnace. Another source of molybdenum is lead molybdate, wulfenite, which is fused with soda ash and carbon to produce lead bullion, and sodium molybdate slag. The slag is then smelted in the electric furnace, with carbon as a reducing agent, and suitable fluxes, to produce ferromolybdenum.

The standard grade of ferromolybdenum is not well established. Some manufacturers make a product containing 50 to 80% molybdenum and 3% carbon, and manage to sell it. Others, by different methods, make a product containing less than 1% carbon. A great deal of ferromolybdenum containing 0.25% sulphur has been sold, but most consumers will not accept a product containing over 0.1% sulphur. Ferromolybdenum containing 80% molybdenum has a dull gray iron color, coarse structure, high density, and is non-magnetic. It does not break easily.

Ferro-Uranium

All ferro-uranium manufactured in this country is derived from the carnotite ore of Colorado. To put the uranium in a suitable form for the production of ferro-uranium, the ore is first subjected to a wet treatment which has as its main object the extraction of radium, with uranium oxide and vanadium oxide or iron vanadate as byproducts. Ferro-uranium was developed not because of any particular need for uranium in steel manufacture, but because of the large quantity of sodium uranate, $Na_2U_2O_7$, that was accumulating as a by-product of radium production. As the reduction temperature of uranium oxide by carbon is 1490° C., the electric furnace is the only available means for per-

forming the operation in quantity. The furnace used in the experiments was a small tilter of the Siemens type, with a steel bottom contact, a rammed magnesite bottom, and a graphite electrode of 4-in. diameter. The power input was 30 to 40 kw. Considerable reactance was connected in the circuit, giving a furnace em.f. of 30 to 60 volts.

Manufacture of Low-Percentage Alloy

Preliminary experiments were directed to the production of a 15% alloy, as several steel manufacturers preferred to try this grade first. Sodium uranate was charged, with petroleum coke as a reducing agent. This 15% ferro-uranium contained 3% carbon, and it seemed impossible to reduce this percentage.

At the start, uranium exhibited one of its fundamental characteristics, its strong affinity for carbon and its tendency to form carbides. Also, in this early work it was found that no fluxing material except fluorspar could be used with sodium uranate; if either lime or silica was added, the uranium remained in the slag with practically no reduction. Here was exhibited its second characteristic, its strong affinity for oxygen, the effect of which is shown in all later work. Because of its high atomic weight, uranium does not hold a large quantity of oxygen, but retains tenaciously the small quantity which is in combination.

The materials used in the manufacture of uranium metal are uranium oxide and petroleum coke. Both of these materials should be low in impurities, especially in iron and silica. The most suitable medium for the production of uranium metal is a stationary Siemens electric furnace, having the crucible bottom as one electrode and a single suspended electrode. The lining is ground, dead-burned magnesite, rammed into place with pitch as a binder, and the bottom electrical connection is made by a small graphite rod buried in the magnesite. Fireclay tiles of hexagonal cross-section also may be used for a furnace.

Furnace Operation

Uranium oxide and petroleum coke are mixed in proper proportions and charged slowly into the furnace. To secure the proper temperature, the furnace must arc all the time. Regular charging is necessary. The uranium metal is allowed to form a sponge on the bottom of the furnace, which gradually builds up. Directly beneath the upper electrode, this sponge is pasty, but not fluid. The charge forms its own furnace lining. When a run is finished, the button of uranium metal is removed from the furnace. The unreduced residue is re-treated with another charge.

The reaction involved is a simple carbon reduction, and the product consists of a mixture of metallic uranium and uranium carbide.

$$UO_2 + 2C = U + 2CO$$
$$U_3O_8 + 8C = 3U + 8CO.$$
$$3UO_2 + 5C = U + U_2C_3 + 2CO$$
$$U_3O_8 + 11C = U + U_2C_3 + 8CO.$$

A typical charge for the production of uranium metal would be: uranium oxide, 20 lb.; petroleum coke, 2 lb., the oxide containing 94.7% U_3O_8, and the petroleum coke, 85% fixed carbon. Making a recovery of 56% of the uranium, 100 lb. of this charge will produce 44 lb. of uranium metal. By resmelting the residue, practically all of the uranium can be recovered except the small amount lost mechanically. The uranium metal made from this charge contained uranium, 93.0%; carbon, 4.39; silicon, 1.43; iron, 1.35; vanadium, 1.31; phosphorus, 0.051; sulphur, 0.13 per cent.

Standard commercial ferro-uranium contains 35 to 50% uranium and 1.5 to 4% carbon. Ferro-uranium is brittle, has a high density, and when it contains over 20% uranium has a tendency to be pyrophoric, this tendency increasing with the percentage of uranium. A 3 to 5% carbon alloy, with less than 15% uranium, has a dense non-crystalline structure, and is dull gray in color. When the uranium content reaches 18 to 20%, small bright crystals appear; and as the alloy approaches 50% uranium, these crystals become larger, longer, and more distinct. From 18% up, the alloy has a brilliant, flaky fracture. At 18% it is hard to break, but at 50% uranium it breaks easily. With the commercial 50% alloy no graphitic carbon is present if the total carbon is under 5%, but if there is over 5% carbon, this excess carbon is usually graphitic. Any of these alloys has an entirely different appearance if cooled from a white heat in water, this treatment giving it a granular and dirty aspect. If the carbon is less than 1.5%, the alloy has a dense gray appearance and is difficult to break. Under the microscope, the uranium appears to be present as the double carbide of iron and uranium, $Fe_2C.U_2C_3$, in a eutectic mixture of iron and carbon.

Uranium metal with over 90% uranium has a dull black color. It is dense in structure, but powders easily. It is very pyrophoric, and draws a long spark when struck across steel or another piece of uranium metal. Uranium carbide is also pyrophoric, but is more flaky in structure than a mixture of uranium metal and uranium carbide.

Owner's Duty To Safeguard Dangerous Premises Affirmed

By A. L. H. Street*

A mining company maintaining a slush pond into which flowed washings from an ore washer, in a community where livestock was permitted to run at large on the commons, was bound to foresee the natural tendency of a mule to stray upon the premises, allured by inviting pasturage; and the company was liable for loss of the animal due to his walking upon an incrusted surface of the pond, which he did not know, but which the company should have known, was insufficient to bear the weight of stock. The Alabama Court of Appeals made this holding in the case of Hudson *vs.* Auxford Brown Ore Co., 77 *Southern Reporter*, 243, as an abstract proposition of law, conditioned upon proof that the company might reasonably have foreseen that stock would probably be lured to the premises and perish, unless precautions were taken to prevent such consequences. This decision follows the principle applied by other courts in other cases where it has been held that the owner of an unguarded hole or abandoned shaft may be held responsible for such accidents to persons wandering across unfenced lands as might reasonably have been foreseen and guarded against.

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Metallurgical Treatment of Radium Ores*

The Commercial Ore of Radium Contains From 5 to 10 Mg. of Radium Element Per Ton — Separation of the Radium Compounds Is an Intricate Chemical and Physical Process

By RICHARD B. MOORE†

THE average commercial ore from which radium is extracted contains from 5 to 10 mg. of radium element per ton. Allowing for losses in extraction and recovery, it takes 5000 or 6000 tons of ore to give an ounce of radium element. It can be seen, therefore, that the metallurgical processes involved in the extraction of radium are entirely different from those connected with any other element. There are two general steps which must be followed: first, to obtain a radium concentrate from the ore, and, second, the re-treatment of this concentrate in order to extract a high-grade product. The first is necessarily on a large scale; the major part of the second is done in the laboratory.

The different methods of treating radium-bearing ores to obtain a concentrate may be classed under three general heads: (1) an alkaline leach, followed by an acid leach; (2) fusing the ore with a material that will disintegrate it and make the extraction of the valuable contents possible; (3) an acid leach.

Alkaline Leach Methods

It is probable that some of the early experimental work on extracting radium from carnotite ore involved boiling the ore with a solution of sodium carbonate, thus getting rid of the uranium and vanadium, which go into solution. As radium has properties similar to those of barium, any radium in the ore would be converted into radium carbonate, and on treating the residue with dilute c. p. hydrochloric acid the radium would be dissolved with any other acid-soluble products.

The radium concentrate always obtained is radium-barium sulphate. By adding barium chloride and sulphuric acid, or sodium sulphate, to the slightly acid solution carrying the radium, barium sulphate is formed in the solution and drags down radium sulphate with it. The radium is almost always precipitated in this manner in a liquor sufficient in volume to hold it actually in solution. Undoubtedly adsorption has something to do with the precipitation of the radium along with the barium sulphate, but this does not fully explain the small losses that accompany such precipitation.

The general principles outlined above are included in the Haynes-Engle process, which involves boiling the ore with an alkaline carbonate solution. The object of this process was to recover uranium and vanadium only, and did not attempt to obtain the radium in any form. A patent taken out by Warren F. Bleeker involved the extra step which the Haynes-Engle process did not cover—the leaching of the residues with hydrochloric acid to obtain the radium in solution, after the ore had been boiled with an alkaline carbonate solution.

The alkaline leach method separates the uranium and vanadium from the ore during the first stage of the process. It eliminates sulphates by converting the metallic sulphates in the ore into metallic carbonates and soluble sulphates which go into the filtrate with the uranium and vanadium. The radium is therefore left behind in the residue as carbonate, practically free from sulphates. This prevents the re-precipitation of the radium as sulphate, on treating with acid, until after the acid solution is filtered from the tailings. On the other hand, it has the following disadvantages: It converts some of the silica in the ore into sodium silicate, which makes filtration difficult—in fact, most of the filtering and washing must be done by decantation. It is difficult to treat concentrates obtained by this process, as these are almost invariably of fine mesh, which adds to the filtration difficulties. The treatment with alkaline carbonate converts most of the iron and a good part of the aluminum in the ore into an acid-soluble form, so that the acid consumption is high. The method, however, can be used with success for the treatment of certain uranium ores, particularly carnotite, autunite, and torbernite.

Fusion Methods

The first method used for the extraction of radium was to fuse pitchblende ores with sodium sulphate. This method was originally used by the Austrian government in connection with the treatment of pitchblende ores from its mines in St. Joachimsthal. By this fusion, the uranium in the ore is changed to sodium uranate, which can be dissolved from the insoluble residue by dilute sulphuric acid, after leaching out the excess of sodium sulphate with water. The radium remains behind with the residue, and before the discovery of radium it was discarded. Afterward, the residue was boiled with sodium carbonate, which converted a part of the radium sulphate into radium carbonate, and this was leached out with dilute hydrochloric acid. After repeating this process several times, practically all of the radium was leached from the residue, and the acid leaches were combined. Barium sulphate was then precipitated in the acid solution in the ordinary manner, and in this way the radium was obtained as a concentrate with the barium sulphate.

A somewhat similar treatment is given to the ores from Olary, South Australia, by the Radcliffe process. The main uranium mineral is carnotite, but this is associated with considerable quantities of ilmenite and other rare-earth minerals that are not found in American carnotite. The concentrates are mixed with three times their weight of salt-cake, and fused in a reverberatory furnace. The fused product is then crushed and agitated in wooden vats, with water. By suitable adjustments it is possible to separate on the bottom of the vats a considerable amount of comparatively coarse material that is almost free from radium and uranium. The turbid overflow carries in suspension the radium, lead, and

*An excerpt from a paper presented at the Colorado meeting of the A.I.M.E., September, 1918.

†U. S. Bureau of Mines.

barium, as sulphates, together with a considerable amount of finely divided silica. The overflow is pumped to large lead-lined tanks and allowed to stand all night. This is nothing but a sliming process and has the advantage that the radium in the form of sulphate always remains with the fine material. The slimes settle completely in 12 hours and are collected periodically and treated for the recovery of radium.

The Schlundt Method

The process of Schlundt, which is being used by one company in the United States in connection with carnotite, is similar to the Radcliffe process. The ore is fused with acid sodium sulphate, leached and washed with water to extract the uranium, vanadium, and other soluble products, and the residue is slimed in order to obtain a crude concentration of the radium, which stays with the fine material.

The U. S. Bureau of Mines has found that if a radium-barium sulphate high in silica is fused with caustic soda containing a small quantity of sodium carbonate, the silica can be easily washed out as sodium silicate, whereas the barium and radium remain behind as radium-barium carbonates, which can be readily dissolved in hydrochloric acid. Usually the commercial caustic soda contains enough carbonate without the addition of an extra amount. This method has been applied commercially to the treatment of crude concentrates, such as are obtained by the Schlundt process.

One firm has used a sodium carbonate fusion. The ore is fused with soda ash, usually about 2½ times the weight of the ore being required. This is done in a reverberatory furnace, lined with magnesite brick, and the fused mass is run directly into vats, in which it is leached. The silica is thus converted into sodium silicate and so passes into solution, together with the uranium and vanadium. The iron, calcium, barium, radium, etc., remain as the insoluble residue, which is washed in filter presses. This material is then treated with dilute sulphate-free hydrochloric acid, which dissolves the carbonates, and the radium and barium are precipitated by the addition of the requisite amount of sulphuric acid, or sodium sulphate. The whole is allowed to stand in settling tanks and the clear liquid is drawn off, leaving the barium-radium sulphates, mixed with a considerable amount of silica and other impurities, as a sludge at the bottom of the tank. This is taken off without previous filtration, and dried, forming a crude radium-barium sulphate, which is then refined.

The main advantages of this method are that it will treat an ore containing considerable quantities of sulphates, as the process removes the sulphates as soluble sodium sulphate in a similar manner to the alkaline leach method. In addition, it is applicable to the treatment of concentrates, as fineness of material is really an advantage instead of a disadvantage, as it does not involve any "sliming." The main disadvantage is the cost, both for the chemicals and the labor required. The concentrate obtained is also of low grade, which involves additional refining costs.

Leaching with hydrochloric acid gives an excellent extraction, provided the ore is comparatively free from sulphates. As a considerable proportion of such ores contain traces of gypsum, it is a method which must be used on selected ores. A hydrochloric acid leach has been used successfully on Cornish pitchblende, which is practically free from pyrite, but is not applicable in any way to American pitchblende, which contains considerable quantities of pyrite. It has also been used on Portuguese autunite. In general, the hydrochloric method is applicable to certain ores, but has a limited use.

Leaching with nitric acid has been used more successfully. This is the method originated by the U. S. Bureau of Mines[1] and used in the plant of the National Radium Institute. As is generally known, barium sulphate is much more soluble in nitric acid than in hydrochloric acid, and this is especially true when the nitric acid is concentrated and hot. For this reason, ores carrying quantities of sulphates can be successfully treated by a nitric acid leach, and the method has been successfully applied to ores carrying as much as 1% gypsum. On ores carrying small quantities of sulphates, the extraction obtained is high, frequently going, on a commercial scale, to 93 and even to 94%. Boiling 40% nitric acid is used, and filtration is obtained on either a vacuum or pressure filter. Filtration must be done rapidly, because, as the acid cools, the radium has a tendency to precipitate out, especially in the presence of sulphates. During the process of recovering uranium and vanadium by this method, practically nothing but sodium hydroxide and sodium carbonate are added to the nitric acid. Consequently, sodium nitrate is obtained as the final product after the precipitation of the radium and vanadium; and this sodium nitrate is recovered by evaporation and crystallization and used over again for the manufacture of nitric acid in the ordinary way. The average losses of nitric acid were about 15%, so that 85% of the acid used was recovered as sodium nitrate. This actually reduced the cost of the nitric acid below that of hydrochloric, and this, together with the high extraction of the radium obtained, was largely responsible for the low cost of the recovered radium and the success of the method.

The process cannot treat successfully ores carrying as large quantities of gypsum as can be treated by some of the other methods, such as the sodium carbonate fusion, but it is applicable to a large percentage of the carnotite ore produced. Difficulty was experienced in treating concentrates, most of which are below 150 mesh. As already stated, it has been necessary to filter rapidly in order to get a good extraction; and the problem of filtering a 40% boiling nitric solution, containing fine material in suspension, was found to be difficult. It was finally overcome by the development and use of a pressure filter instead of a suction filter. This consisted of a steel shell containing an earthenware filter set in concrete. The earthenware filter had at its bottom, as filtering medium, a plate of either filtros or alundum. The steel top was made tight with swing bolts, and a pressure of 100 lb. was applied.

Refining

The radium-barium sulphate concentrate obtained in a satisfactory metallurgical process should carry about 1 mg. of radium element per kilogram of concentrate, a ratio of one to a million. The next step is to get this

[1]Charles L. Parsons, R. B. Moore, S. C. Lind, and O. C. Schaefer: "Extraction and Recovery of Radium, Uranium and Vanadium from Carnotite," U. S. Bureau of Mines Bulletin No. 104 (1915).

concentrate back into solution. The most successful method is to reduce the sulphate with about one-sixth its weight of pulverized charcoal in a furnace at a temperature from 800 to 900° C. In the presence of silica, the reduction takes place slowly and is not complete; but if the sulphate does not contain more than from 5 to 10% silica, the reduction may reach 90% or more. The radium-barium sulphides are then dissolved in sulphate-free hydrochloric acid, and filtered. From this stage on, the refining process is simply one of fractional crystallization. Radium chloride and bromide are less soluble than the corresponding barium salts. The crystals first obtained on evaporation are therefore richer in radium than the mother liquor from which they are obtained. The difference in solubility of the bromides is considerably greater than that of chlorides; at some stage in the process, all of the chloride salts are converted into bromides, after which fractionation is continued as bromide, in hydrobromic acid solution. The factor of separation is higher in acid than in neutral solution. It is customary, therefore, to fractionate both chlorides and bromides in acid solution. Full details of the methods of fractionation are given in U. S. Bureau of Mines Bulletin No. 104.

Methods of Ore Concentration

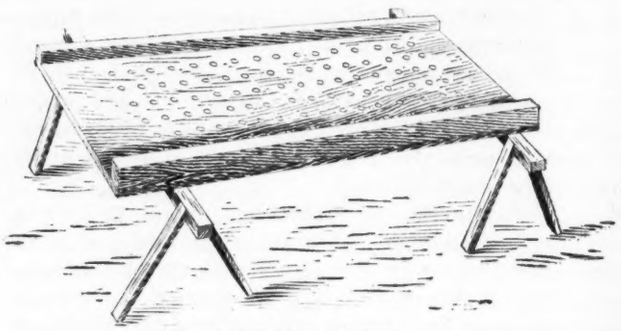
Both wet and dry methods of concentration may be used for carnotite ores. The wet method simply involves crushing the ore and agitating with water in the manner that will best separate the fine-grained particles of carnotite from the coarser silica particles. After allowing to settle, the fine material can be slimed off and run into settling tanks; the coarser tailings are re-leached. The only successful method of dry concentration that has so far been used has involved the Raymond pulverizer and dust-collecting system. The National Radium Institute built a small plant near the claims it was working in Long Park, Colo., and gave the method a thorough testing, with excellent results. The capacity of the mill was a little over one ton of milling ore an hour; and the average output was 365 lb. of concentrate an hour. The milling ore had an average content of 0.85% U_3O_8; the average of all concentrates was 2.92% U_3O_8; the tailings averaged 0.3%; the ratio of concentration was about 6 to 1. As much as 63.7% of the carnotite contained in the milling ore was extracted, and 60% of all the carnotite in this ore was actually recovered in the concentrates.

The Practice and Philosophy Of Ore Sorting*

Following are a few details of practical mining that will prove very useful in ore sorting:

Instead of sorting off of a floor or off of a table, as is usually done, sort off of a horizontal screen placed on two carpenter's horses, as in figure. Screen should be made of light sheet iron (corrugated roofing iron is about right). A screen made of sheet iron is better than a screen made of wire, as the ore can be raked back and forth over it easier. Screening cleans the ore and makes it easier sorted. Placing the screen on tressels makes it possible for the ore sorter to sit in a comfortable position, instead stooping in a back-breaking position, as he has to do when sorting off of a floor.

There should be several screens of different mesh. One screen, on which is placed all ore containing more ore than waste, should have holes big enough to let through all pieces of waste that are so small that it



SORTING TABLE

don't pay to pick them up. The principle difficulty in picking waste out of ore, is to keep from wasting one's time picking up pieces of waste that it don't pay to pick up. The other screens, on which is placed ore that contains more waste than ore, should have smaller holes than the first screen. The holes should be of a size that they will only let through waste that it will not pay to pick the ore out of. The smallness of the holes will depend on the proportion of ore to waste; less the ore, smaller the holes.

An ore sorter's work should be judged by the amount of waste he picks out of the ore. Waste has a value determined by the freight and treatment charges. If a man's wages are more than the freight and treatment charges of the waste he picks out, there is no use of him sorting. I have seen two men put in two days picking about 50 lb. of waste out of some rich ore—they thought because the ore was rich that it should be sorted closer. It cost about $16 to pick out the 50 lb. of waste. To ship and treat the same waste would of cost about 50c., where shipping and treating cost about $20 per ton. Waste in rich ore is not worth any more than waste in poor ore. The amount of waste that must be picked out of an ore in order to pay, varies with the cost of transportation and treatment. Greater the cost of transportation and treatment, smaller the holes in the screen should be.

Considering the simplicity, the cost and the benefits. sorting off of a horizontal screen placed on tressels ought to find ready acceptance as a useful addition to the many details of practical mining.

*[As a contribution to the discussion on the advisability of sorting ore previous to metallurgical treatment, the views and suggestions submitted will lose none of their force, nor the arguments their logic, by appearing as received, and without having been molded to conform to the Journal's usual style. We work, necessarily, under an accepted system of typographical and publication rules, which, in such instances as the present contribution, are sometimes broken to prove their real flexibility.—Editor.]

The Gigantic Figure of 7,397,553,000,000 was given as the total probable world's coal tonnage in 1913, on the authority of the International Geological Congress held in that year in Canada. This estimate was obtained after an exhaustive analysis had been made of the opinions and calculations of experts in all the countries of the world, and refers to the coal existing from the surface to a depth of 6000 ft. Of this huge total nearly 50% is found in the United States. Great Britain is in a much less fortunate position, although the quality of the Welsh coal is exceptionally high.

Petroleum in Colorado

Colorado began petroleum production in 1887. It now produces about 200,000 bbl. per annum. The maximum production was 501,000 bbl., in 1904. In 1916 the average price received at the wells was $1.10 per bbl., and the value of the output was $217,139 (197,235 bbl.). Production comes principally from two fields, the Boulder and the Florence. Of these the Florence field is the more important, as it furnishes 95% of the Colorado production. The oils produced are principally of paraffin base and are suitable for refining by ordinary methods.

The Rangely district, in Rio Blanco County; the De Beque, in Mesa County, and oil-shale land areas in Garfield County are considered of importance as prospective petroleum producers. Some production has been made from wells, but it is not improbable that the distillation of the petroliferous shales can be established as a profitable industry. The proof of the commercial potentialities of the oil-shale areas can be established only by experimental distillation on a commercial scale.

The Government has classified 3,692,036 acres of oil-shale land in the West. During the last year two oil-shale reserves were created for the use of the Navy, one of 45,440 acres, in Colorado, and the other in Utah.

In Colorado, according to the U. S. Geological Survey, it is estimated that the shale deposits are capable of yielding 20,000,000,000 bbl. of crude oil, giving upon refining 2,000,000,000 bbl. of gasoline, and those of Utah may produce an equal amount. The Colorado shale will probably also produce about 300,000,000 tons of ammonium sulphate, a substance useful as fertilizer and for the production of nitric acid for use in explosives. At many places in Colorado and Utah the rich shale has only a light overburden, and could be mined with a steam shovel, in this respect possessing a great advantage over the method of mining oil-shale deposits in Scotland and France. But there are particularly tough layers of shale which wear out steam-shovel teeth rapidly, even those of manganese steel, which will be an important factor in the cost of mining. However, in Scottish oil-shale operations some pits and shafts are 1000 ft. deep, which factor is not present in the Colorado and Utah deposits.

According to J. C. Morrell and Gustav Egloff, the average of 51 samples of Colorado shale which were retorted gave an oil gallonage of 16.2. Of the 51 samples, 29 were tested for ammonium sulphate, with an average of 7.6 lb. per ton of shale. For the State of Utah the average of 38 samples under similar conditions gave 25 gal. of oil and 5.3 lb. of ammonium sulphate per ton. Wyoming gave 16.4 gal. of oil and 6 lb. of ammonium sulphate per ton as an average of 42 samples retorted. The oil shales of Utah indicate a 40% greater yield of oil per ton than those of the states of Colorado and Wyoming. Twenty samples of the Colorado shales were tested to determine cubic feet of gas per ton of shale retorted, and the average was found to be 2705.

The oil-shale area is at present the most promising in Colorado as a source of petroleum. The great variety of the products makes the commercial development of these deposits highly desirable. Several companies have already started operations, and results, or at least a knowledge of the commercial possibilities, may soon be obtained.

The Crowe System of De-aërating Cyanide Solutions*

BY THOMAS B. CROWE

In the cyanide work in the mills of the Portland Gold Mining Co., oxygen has been found to be the greatest enemy to precipitation. A few years ago I made some bottle tests under vacuum. An acid bottle was partly filled with mill solution and connected by a rubber hose to a vacuum pump. When the vacuum was suddenly applied, a cloud, composed of thousands of small air bubbles, rose out of the solution, showing the amount of dissolved air it contained. The metallurgical results were surprising, indicating that under vacuum practically no gold dissolved, which confirmed my belief that Elsner's equation was true and also led me to investigate the amount of dissolved air carried by solutions at atmospheric pressure.

Large tests were tried, apparatus was designed that would continuously apply a vacuum to solution during its flow to the precipitation presses, and gradually the vacuum system of precipitation worked its way into the company's mills, with the result that the zinc consumption has been halved, which fact is especially gratifying during the war period, with its prevailing high prices.

As the price of cyanide kept soaring, it was decided to try to make a reduction in cyanide consumption. A scrutiny of former work revealed the fact that, for dissolution purposes on this particular ore, the cyanide solution strength was much higher than was necessary. The strongest solution was the barren; and this, being used as a wash on the filters, occasioned high cyanide consumption. The high strength of the barren solution was caused by the necessity of adding lump cyanide at the head of the precipitation plant to insure low-grade solutions for washing.

With the installation of the vacuum system, it was found that perfect precipitation could be maintained without the addition of lump cyanide; and today the Portland Gold Mining Co. mills are running with the highest solution strength in the agitators. This, together with a generally lower solution strength in all parts of the mill, has allowed a material reduction of cyanide consumption.

The accompanying table will give an idea of the amount of cyanide and zinc used before and after the installation of the vacuum precipitation.

COMPARISON OF ORDINARY AND VACUUM PRECIPITATION SYSTEMS AT PORTLAND GOLD MINING CO. MILL

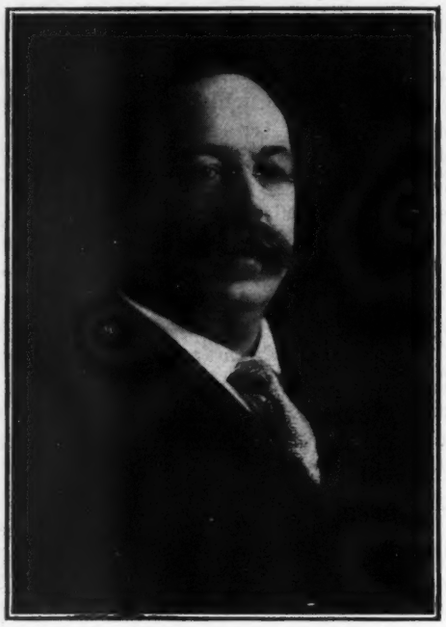
	Tons of Solution Precipitated	Pounds NaCN per Ton Ore	Pounds Zn per Ton Ore	Pounds Zn per Ton Sol.
12 months, 1915	503,819	0.331	0.407	0.174
12 months, 1916	536,455	0.320	0.369	0.150
6 months, 1917	249,988	0.175	0.191	0.084

Years 1915 and 1916, ordinary zinc-dust precipitation. Year 1917, vacuum precipitation.

The Electrolytic Zinc Plant at the smeltery of the Mammoth property of the U. S. Smelting, Refining and Mining Co. started operations in 1917, according to the report for that year. The problem confronting this plant is a novel and difficult one. The material to be treated is the bag-house dust from the smeltery, a complex and troublesome material. The technical features may be considered satisfactorily solved. The mechanical appliances, however, have presented many difficulties, which are gradually being overcome.

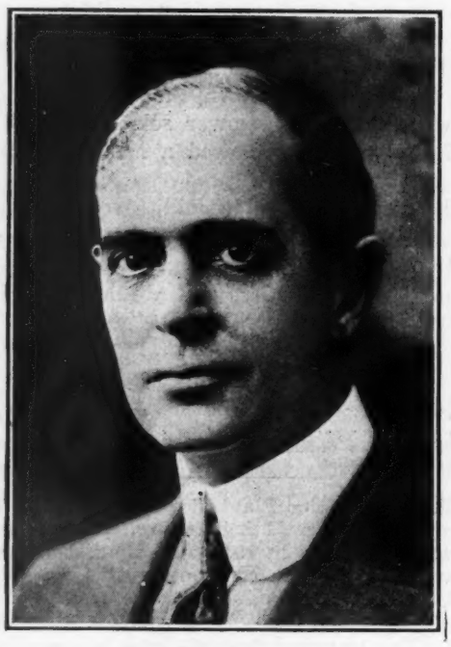
*Excerpt from a paper to be presented at the Colorado meeting of the A.I.M.E., September, 1918.

Prominent Colorado Mining Engineers

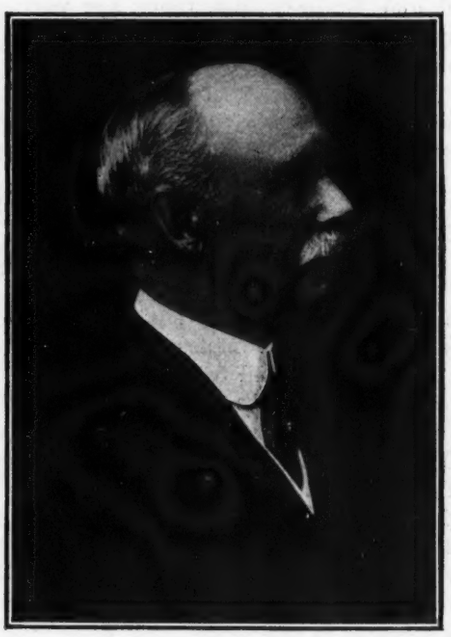


PHILIP ARGALL

GEORGE O. ARGALL



BULKELEY WELLS



D. W. BRUNTON

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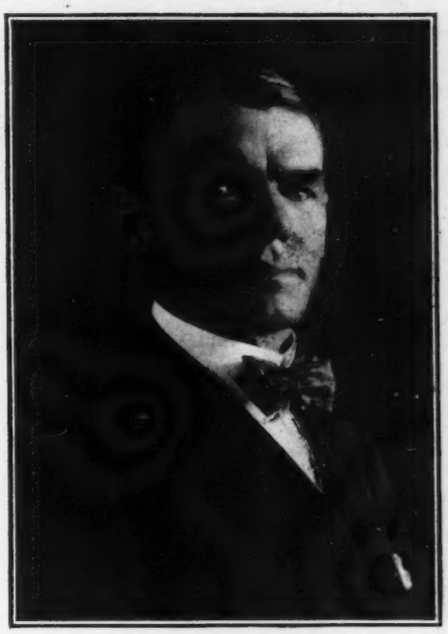
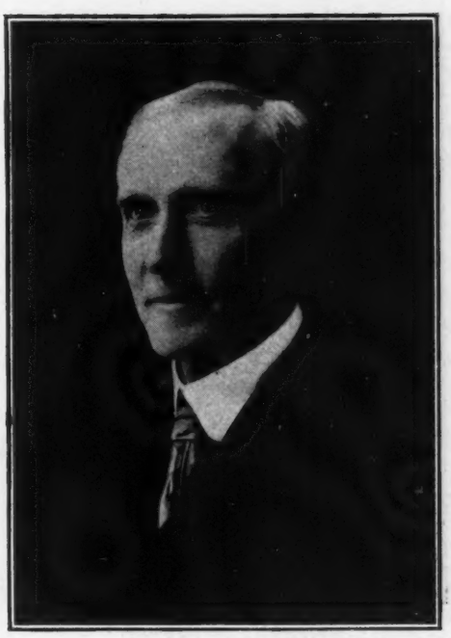
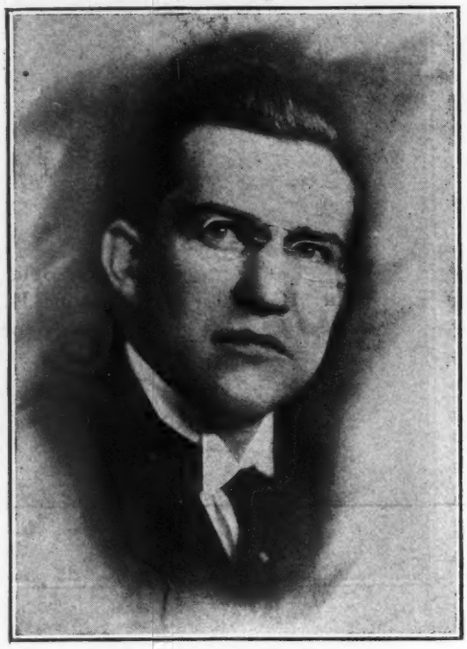


CHARLES A. CHASE

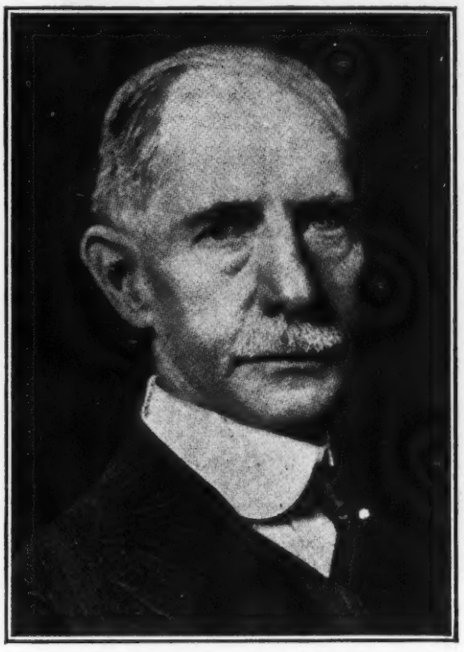
HARRY J. WOLF



VICTOR G. HILLS

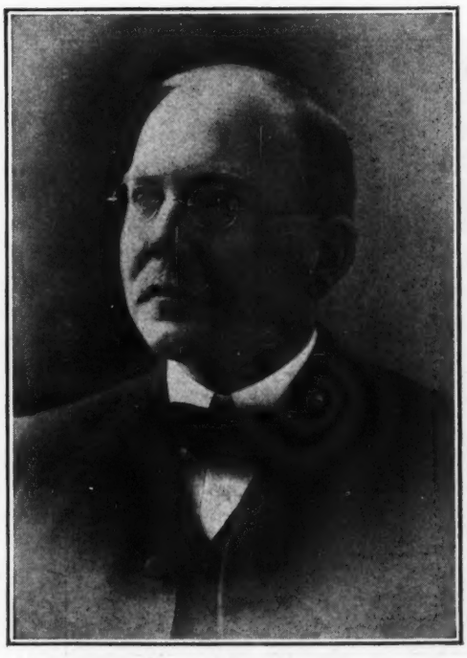


HOWLAND BANCROFT



RICHARD A. PARKER

ETIENNE A. RITTER



GEORGE A. MARSH

Events and Economics of the War

Repeated blows by the French and British on the front between Soissons and Arras, culminating in a heavy attack along the entire line, have given the foe little time to organize his resistance and have brought the British into the outskirts of Bapaume on the old Hindenburg line; the French, after taking Lassigny, are closing in on Noyon, whose downfall is imminent; the number of prisoners and guns captured is constantly growing. The Germans are continuing their withdrawal along the Lys. Spain, after many denials, has admitted notifying Berlin that she will seize interned German vessels to replace those sunk by U-boats. Word from Russia states that the Bolshevik "Reds" declared war on America on Aug. 2. North of Vladivostok, Czecho-Slovak and Allied troops have been forced to fall back. Widespread riots over the price of rice have occurred in Japan.

At Washington, the Man-Power bill is the center of attention; the bill has passed both houses. Secretary Baker advocated the passage of the Sims Water-Power bill before the Interstate Commerce Commission, declaring he favored Government ownership of power plants. Fuel Administrator Garfield refused to allow an increase in coal miners' wages. In reporting its findings, the Senate committee investigating airplane production charged that most of the $640,000,000 appropriated was thrown away. Sweden has entered into an agreement with the United States and others of the Allies to furnish 400,000 tons of shipping and certain products, including rich Swedish iron ores.

American Gold Conference Organized

Relief by the Government for the gold producers of this country to correspond with the increased cost of production, the extent of such relief to be fixed from time to time to meet changing conditions, was said at the meeting of the American Gold Conference, held in Reno, Nev., on Aug. 12 to 14, to be the most effective measure yet proposed to maintain and encourage production of gold in the United States. The conference passed a formal resolution to this effect, which was not to be construed, however, it was said, as recommending any change in the amount of gold in the dollar, or the placing of a premium upon the metal. It was pointed out that under present conditions capital not only cannot be obtained for gold mining, but is generally being withdrawn, wherever possible, from the industry.

The conference was presided over by Governor Emmet D. Boyle, who said that the purpose of the convention was to bring together all interested in the production of gold to consider plans to relieve the present situation. During the first session Governor Boyle was elected permanent chairman and Mayor Frank J. Byington, of Reno, vice chairman. Addresses were delivered by the following: J. F. Callbreath, secretary of the American Mining Congress; John G. Kirchen, of Tonopah, Nev.; H. N. Laurie, of Portland, Ore., chairman of the Oregon Bureau of Mines; Whitman Symmes, of Virginia City, Nev.; W. C. Ralston, of San Francisco; Courteney De Kalb, and John Clausen of San Francisco.

A permanent organization was decided upon, and the following general committee was appointed: I. Pett, Utah; Bulkeley Wells, Colorado; J. A. Burgess, Arizona; George T. McGee, Montana; Robert N. Bell, Idaho; B. L. Thane, Alaska; H. N. Laurie, Oregon; E. H. Clark, South Dakota; S. J. Kidder, New Mexico; John G. Kirchen, Nevada; Milnor Roberts, Washington. The following were appointed as an executive committee: Emmet D. Boyle, W. J. Loring, Bulkeley Wells, Whitman Symmes and George W. Starr.

The committee on resolutions appointed during the first session consisted of the following: James F. Callbreath, Washington, D. C.; E. C. Hutchinson, Jackson, Calif.; W. J. Loring, San Francisco; Bulkeley Wells, Denver; John G. Kirchen, Tonopah, Nev.; W. C. Ralston, San Francisco; H. N. Laurie, Portland, Ore.; Prof. Carl Plehn, Berkeley, Calif.; John Fulton, Melones, Calif.; J. A. Burgess, Oatman, Ariz.; Fletcher Hamilton, San Francisco; George W. Starr, Grass Valley, Calif.; John Clausen, San Francisco.

A resolution by G. McM. Ross, requesting the governors of the different gold mining states to use their influence to prevent the dismantling of gold mining properties, was referred to the general committee. A subscription was taken to secure money for the immediate needs of the organization. Permanent offices will be opened in Reno, where the business of the organization will be conducted. Eugene Davis was selected to take charge of this office. The conference was attended by many well-known mining men from the gold-producing states and other parts of the country.

Mexico Stands Pat on Oil Question

Mexico's new oil decrees separating the title to surface lands from the subsoil deposits, which the government claims, under the new constitution, are not intended to interfere with the oil supply of the Allies, according to Luis Cabrera, Carranza's former Foreign Minister, an interview with whom has recently appeared in the press. The oil producers concerned seem less optimistic, however, and an association has recently been formed by the important companies to protect their interests

The Mexican constitution among other things provides that royalties received from the production of oil be taxed 50%. The government also issued a proclamation requiring all oil companies to file manifests of the property they own and from whom purchased, together with other details. The decree was modified on Aug. 12, in response to a protest from Washington, to the extent that companies having invested money

in Mexican oil properties for the purpose of developing them need not file the statement called for, but must pay a reguar bi-monthly tax of 50% on royalties paid on output. This, in effect, means that the government demands one-sixteenth of the output of each foreign-controlled well.

Violation of the modified decree will be punished by voiding the operators' claims; in other words, by virtual confiscation. The Allies and the United States need 90,000 bbl. of Mexican oil per week, according to Mark L. Requa, head of the oil division of the U. S. Fuel Administration.

Bonus for Coal Miners an Evil

An increase in the wages of coal miners as a substitute for the payment of bonuses, for the stopping of which drastic steps are to be taken, will not be approved by Fuel Administrator Garfield. President Frank J. Hayes and other officials of the United Mine Workers of America received this answer from the Fuel Administrator on Aug. 23 in response to their request for a flat increase in wages in lieu of the payment of bonuses.

Bonuses were characterized by Dr. Garfield as "an evil." He announced that the first action toward forcing the abandonment of the practice would be a reduction of 20c. a ton in the price of coal in the Cambridge and Hocking fields of Ohio, and a reduction of 5c. a ton in all other Ohio fields except the Eighth District. From these fields, it was said, were received most of the complaints as to the payment of bonuses.

In spite of this attitude on the part of the Fuel Administration, the United Mine Workers of America have appealed to Dr. Garfield for a reopening of the wage question.

Polish Iron Furnaces Lack Ore

In Russian Poland before the war there were 125 iron furnaces, according to the *British Ironmanger's* translation from *Stahl und Eisen*. Eleven of these were blast furnaces, 27 were open-hearth, 62 reheating and the rest puddling furnaces. At Dombrova, where the furnaces were blown in again last fall, the chief works are Huta Bankowa, which previous to the war had Russian support, as the operating company was French. Rails, axles and wheels came solely from these works, the others supplying mainly sheets and merchant iron. Two spelter works which belonged to the Société Minière Franco-Russe are also at Dombrova.

The inadequate supply of ore from South Russia placed the Polish furnaces before the war at a disadvantage compared with those in South Russia, but the German periodical states that Austrian ore will be furnished the Dombrova stacks as far as possible. The lack of raw materials will probably continue to prevent the blowing in of other furnaces, though the important Milovitz iron works, which formerly produced mainly merchant iron, wire and railroad accessories, has repeatedly sought permission to resume operations. An expansion of its plant by this company a few years before the war has so far been useless to it. There are even some firms belonging in whole or part to German interests that are in similar straits owing to the lack of raw materials.

Limits Set to Coal Storage in East

A meeting of state fuel administrators from all states east of the Mississippi as well as from Minnesota, North Dakota and South Dakota was held in Washington on Aug. 20, to consider ways of securing bituminous coal for special war purposes in the Eastern part of the country, particularly for the Navy and transport purposes, without disturbing the supply moving to other industries. The demand for this coal is rapidly increasing, according to a bulletin of the U. S. Fuel Administration, so that it has become necessary to draw more heavily on Eastern coal fields than was originally contemplated.

At this meeting it was decided that to accomplish the desired result it would be necessary to limit the amount of coal that industrial plants would be allowed to carry on hand and to fix a uniform amount for each state. The maximum limits of storage of steam coal, byproduct and gas coal for public utilities, preferred industries and non-preferred industries in the states concerned have been indicated in a committee report adopted by the meeting and concurred in by Dr. Garfield. Preferred industries will be allowed to carry from 20 to 60 days' supply of steam coal, depending on the state, with the exception of Maine, in which a 90-day supply will be permitted. Non-preferred industries in these states may accumulate from 15 to 30 days' supply of steam coal.

U. S. Technical Employment Bureau

The privileges of the Division of Engineering of the U. S. Employment Service are open, free of charge, to all engineers and technical men. To make use of them, all that is necessary is to apply to the nearest branch of the U. S. Employment Service. For additional information and for application blanks one should address the department, Division of Engineering, U. S. Employment Service, Chicago, Ill. Whether in need of war work or not, every technical man is advised by A. H. Krom, head of the division, to apply at once for blanks, so that he may record his ability with the Government and thereby at any future date secure a position, without any charge whatever.

The record for last month of the Division of Engineering offers testimony as to the amount of work it has done in a very short time. In this period, the division has received 468 applications for help from employers; 1314 applications for help from workers; has referred out 1063 applications, and actually placed 483 men.

Control of Sulphur-Bearing Materials

In our issue of Aug. 17, a statement was made to the effect that sulphur and pyrites consumers' answers to a questionnaire should be sent to the Sulphur Committee, 15 William Street, New York. They should be addressed care of A. D. Ledoux.

The Service Bureau (F. W. McReynolds, Director) of the Committee on Public Information, the office of which is at 15th and G Streets, Washington, is organized to supply information respecting Government officials, their functions, and the situation of all Government departments. Persons needing such an official guide in Washington will do well to bear this in mind.

Dr. Douglas' Will

The will of James Douglas was filed in the Bronx Surrogate's office on Aug. 20. It disposes of an estate valued at approximately $20,000,000. Under the will the American Institute of Mining Engineers, 29 West 39th St.; the American Museum of Natural History, and the Kingston General Hospital, Kingston, Ontario, receive definite bequests of $100,000 each, and McGill University, Montreal, is to get $50,000. Bequests of from $5000 to $50,000 are made to relatives in Canada and England. To the widow, Mrs. Naomi Douglas, the real estate in Riverdale and in Spuyten Duyvil is given, together with the home and stables, personal property and securities which are expected to yield an annual income of $50,000.

A trust fund of $400,000 is created and placed in the hands of two sons, James Stewart Douglas and Walter Douglas, for two grandchildren, Wilmot Douglas Hayter and Herbert Cecil Hayter, of Flamborough, England, who are to receive the bequest when the younger of the two becomes of age. The father of these two boys, Colonel Herbert Ross Hayter, now fighting in France, is to get $50,000. Children of the testator are to receive annuities in the following amounts: Elizabeth Douglas, $5000; James Stewart Douglas, Walter Douglas and Edith Mary Douglas, $2500 each.

Six workmen on the Spuyten Duyvil estate receive $2000 each, and four $1000 each, and all in the employ of the estate more than five years are to receive $500 each. Four house servants are to receive $2000 each, one is to receive $1000, and all over two years in the employ of testator are to receive $500. The residuary estate is divided equally among the four children.

In the will the testator states that he was at one time the manager of an insane asylum, and that his father had been impoverished by mining swindlers. At the age of 40, the testator states, he took up the study of mining engineering and began operating in Canada, Mexico and the United States, with the result that fortune smiled upon him abundantly.

Oil From Shale Rock

With the demand for gasoline and for the crude oil from which it is made, as well as for the ammonia to be used in fertilizers, growing more and more imperative, it is encouraging to learn that rapid progress is being made in producing these materials from the oil shales that are found in the Western States, especially in Colorado, Nevada, Montana, Utah, and Wyoming. More than a dozen large companies have been organized to win oil from these shales and are now making experiments to determine the most efficient and economical way of doing so. Aërial tramways are being built to bring the shale from mines, to be opened high on the sides of the mountains, down to retorts or distillation plants to be built in the valleys near water and lines of transportation.

Chemists are finding that a great many useful things can be made from the oil shales—such as dyes, explosives, paints, fertilizers, and substitutes for rubber, as well as gasoline, kerosene, parafin, and flotation oil—but the industry is not yet far enough advanced to enable any one to tell which of these products, or how many of them, can be manufactured at a profit. The industry must eventually succeed, but its success may depend largely on the profits derived from the sale of the byproducts.

A report[1] recently published by the U. S. Geological Survey shows the results of geologic examinations of oil shale in the Uinta Basin, Utah, by D. E. Winchester, and gives records of distillation and tests of samples of shale collected elswhere in the United States. The oil shale in Utah is black or brownish black, except on weathered surfaces, where it is bluish white or white. It is fine grained, slightly calcareous, and generally free from grit. It is tough, and its thinner beds are remarkably flexible. Its flexibility distinguishes it from ordinary carbonaceous shale, which is brittle. When ignited with a match a thin splinter of oil shale burns with a sooty yellow flame and gives off an asphaltic odor.

Oil shale is heavier than coal, having an average specific gravity of about 1.6, but the richer shales are not so heavy as the leaner ones. The oil shale of the Green River formation contains about 60% of ash. As good coal contains less than 10% of ash, oil shale cannot be profitably used directly as fuel. In order to obtain its content of oil, the shale must be mined like coal, crushed, and distilled in huge retorts, in which it gives off crude shale oil, ammonia, and fuel gas, products from which may be made a number of valuable substances. Though some of the shale has on distillation yielded more than 2 bbl. of oil to the ton, little of the oil is in the shale in the form of oil. The shale contains a great mass of partly bituminized vegetable matter, which can be converted into oil by heat.

Colorado Mine Adits

The rugged topography of Colorado and the occurrence of many steeply inclined veins have made the development of such veins by adits attractive to miners. Deep drainage has also imposed upon Colorado miners the necessity for constructing long adits. The table below comprises mining companies developing through adits and also gives the length of the adits:

COLORADO MINE ADITS	Length Adit, Feet
Argo Mining, Drainage, Transportation and Tunnel Co., Idaho Springs	21120
Atlas mines, Sneffels	7800
Laurium mine, Breckenridge (Blue Flag Gold Mining Co.)	1800
Camp Bird Mining, Leasing and Power Co.	2100
Camp Bird, Ltd.	10000
Carbonero Mines and Reduction Co.	2700
Carter Mining Co., Ohio	7850
Colorado Central Mining Co., Georgetown	4700
Commonwealth Mining Co., Alma	1800
Creede Exploration Co., Creede	3600
Dinero Mining and Tunnel Co., Leadville	4500
Eagle Rock Tungsten Production Co., Boulder	3000
Excelsior mines, Frisco	1400
Hahn's Peak Gold Mining and Milling Co., Columbine	1275
Hope Mining and Milling Co., Aspen	5644
Lackawanna Mining and Reduction Co., Silverton	1200
Mary Murphy Gold Mining Co., Romley	4500
Midwest Metal Mining Co., Denver	1300
Mineral County Mining and Milling Co., Creede	15000
North Fork Power and Mines Co., Salida	1250
Ophir Loop Mines, Ames	1800
Rawley Mining Co., Bonanza	6325
Roosevelt Tunnel, Cripple Creek	23000
Sandy Hook Mining and Milling Co., Ohio	1800
Smuggler Union, Telluride	7000
Sunnyside M. and M. Co., Eureka	1200
Tomboy Gold Mines Co., Ltd., Telluride	5000-10000
Tonopah Belmont Development Co., Dunton	3300
United States Gold Corporation, Sugar Loaf	1600
Western Gold Mining Co., Alma	3600
Yak Mining, Milling and Tunnel Co., Leadville	16000

[1]Bulletin 691-B, U. S. Geological Survey.

A GROUP OF OFFICERS OF THE 27TH ENGINEERS

Two of a Kind

AN ISSUE of the Journal such as the present, devoted largely to the war meeting of the Institute to be held in Colorado during the coming week, would be incomplete without some reference to that other body of mining men engaged in war work, the 27th Engineers, many of whom are members of the Institute. As representative of the mining industry as the Institute itself is the mining regiment, the men of which have been drawn together from every mining district of the country. We have been fortunate in securing a photograph of a group of the regiment's officers, which is shown on this page. A brief account of the organizing of the regiment, written by Private E. Hall, of Company D, has recently appeared in the *Bullet*, published at the Navy rifle range at Glenburnie, Md. Private Hall says in part:

When the regiment was first authorized, Mr. O. B. Perry (now Lieutenant Colonel), consulting and mining engineer and general manager of the Yukon Gold Co., was selected by the War Department to organize and command the 27th. When regimental headquarters was moved to France, Lieut. Col. Gilmore, who served as a government engineer in the construction of the Panama Canal, was attached to the regiment to command the Second Battalion. Capt. Norval J. Welch, of Company A, the first company to be sent across, is a mining engineer. Capt. Ward Royce, a mining engineer, was prior to entering the service managing a mining property in Mexico. Capt. F. S. Norcross, of Company C, was superintendent of the Canada Copper Corp., of British Columbia, and is a mining engineer. Capt. R. E. Franklin, commanding Company D, an electrical engineer, was superintendent of the power and water supply of the Yukon Gold Co., in the Yukon Territory and Alaska. Capt. C. D. Brown, of Company F, a mining engineer, has been in charge of a large mining property in the British Congo. Capt. H. L. Jacques, of Company F, is a civil and mining engineer from Arizona and California. The other officers of the regiment are from all over the continent and are civil or mining engineers.

Lieutenant Colonel Gilmore is a veteran of the Cuban war. Captain Franklin and First Lieutenant Burnside, of Company D, are veterans of the Philippine insurrection, as is Captain Brown, commanding Company E. Many of the enlisted men of the regiment are also veterans of the Spanish-American War.

Our friends are urged to let others share any news they may receive from the men of the Twenty-seventh. What interests one may interest many. Make the *Journal* a clearing-house for news of the mining regiment—and don't forget the Comfort Fund.

HOW THE COMFORT FUND STANDS

Previously acknowledged	$13,664.00
Students of Wisconsin Mining School	50.00
A. M. Plumb	5.00
C. W. Snow	2.50
Charles A. Mitke	5.00
A. A. Hassan	10.00
A. A. Hassan, Jr.	5.00
Emin A. Hassan	5.00
Bernard MacDonald	5.00
C. F. Rand	50.00

Calumet & Arizona Mining Co. and New Cornelia Copper Co.	400.00
Oscar Lachmund (fourth contribution)	10.00
C. N. Bell	10.00
C. S. Witherell	25.00
W. G. McBride	25.00
Karl Eilers	50.00
R. T. Hancock	5.00
E. E. White	100.00
S. Ringlund	10.00
H. Foster Bain	10.00
Marc Bailey	10.00
Charles Le Vasseur (second contribution)	10.00
William Wraith	25.00
H. A. Wheeler	10.00
Nevada Mine Operators' Association	100.00
Louis R. Wallace	50.00
H. P. Bowen	5.00
H. L. Brown and M. W. Hayward	16.00
Iron Cap Copper Co.	50.00
W. N. Smith	10.00
E. S. Geary	5.00
H. J. Wolf	10.00
F. H. Siebold	10.00
H. A. Kee	10.00
W. S. Grether	5.00
Marion J. Thomas	10.00
E. F. Eurich	10.00
Liberty Bell Gold Mining Co.	200.00
H. De Witt Smith	15.00
Associated Miners of the University of Idaho	10.00
New Idria Quicksilver Mining Co.	100.00
F. P. Burrall	25.00
Livingston Wernecke	5.00
E. P. Mathewson	50.00
Interest to June 26	82.61
H. W. Hixon	10.00
R. C. Canby	10.00
S. R. Guggenheim	100.00
Richard Tavis	5.00
Simon Guggenheim	100.00
J. V. Kelley	10.00
Algernon Del Mar	4.00
Sumner S. Smith	5.00
Will H. Coghill	10.00
Lincoln Crocker	10.00
C. E. Dewey	10.00
Plymouth Consolidated Gold Mines, Ltd.	100.00
United Eastern Mining Co.	50.00
W. A. Wilson	20.00
Oscar Lachmund (fifth contribution)	10.00
W. Rowland Cox	10.00
L. D. Huntoon	5.00
Alaska Mining and Engineering Society	50.00
W. R. Benedict	3.00
Etheredge Walker	25.00
Fritz Mella	10.00
Richard McCarthy	10.00
J. N. Houser	10.00
Weedon Mining Co.	50.00
William H. Kinnon	30.00
A. P. O'Brien	10.00
Lester W. Strauss	10.00
Montana Society of Engineers	50.00
W. R. Atkeson	2.50
Charles Le Vasseur (third contribution)	5.00
Frank Carroll	10.00
V. P. Hastings, Jr.	5.00
D. E. Woodbridge	5.00
Harvey B. Small	10.00
J. C. Porter	10.00
A. F. Taggart	10.00
G. E. Farish	25.00
H. K. Sherry	10.00
T. M. Hamilton	50.00
George O. Argall	10.00
C. T. R.	15.00
Oscar Lachmund (sixth contribution)	10.00
Total	$16,184.61

Make your checks payable to W. R. Ingalls, treasurer of the Association of the 27th Engineers.

The Sulphur Controversy

The controversy among Government departments respecting sulphur supplies waxes furious, or we might say sulphurous. The alarmist party always admitted privately that there was a large stock of sulphur on hand, but shook its head over the danger of some calamity to the mines, such as a German submarine bobbing up and bombarding them. On Aug. 6 a cyclone swept through a part of Louisiana in which is the plant of the Union Sulphur Co., and did some damage. Here was the opportunity for further exploitation of the hysterical propaganda. Government "experts" were rushed to the scene, and the *Globe* of New York, Aug. 21, came out with a sensational story, under the caption "Sulphur Crisis Alarms Experts." Dr. R. H. McKee and Andrew Murray Hunt were quoted at length as to the desperate situation that would exist *if* our sulphur supply should be suspended. The statements of these gentlemen are qualified with that "if" and it does not appear that they examined the situation in Louisiana, but "Government engineers have finished a survey of the plant," says the press dispatch, and it is understood, according to them, "that the mining of sulphur will not be resumed for many weeks, and maybe the Union Sulphur Co. will not again be a factor in sulphur production for many months." Engineers familiar with the conditions are represented as saying that the great danger of delay lies in the cooling of the ground and the consequent necessity of reheating it before the sulphur can be liquefied again and once more pumped to the surface.

Some bureaus in Washington have received confidential advices to the same effect. On the other hand, the War Industries Board, through the Committee on Public Information, under date of Aug. 23, authorizes the following:

> Advices to the Chemicals Division of the War Industries Board are that mining operations have been resumed in part at the plant of the Union Sulphur Co., at Sulphur, La., where considerable damage was done by the hurricane that swept over that region on Aug. 6. Shipments of sulphur were resumed last week from the accumulated stocks, and rapid progress is being made in the work of restoring normal conditions. Considerable rebuilding will have to be done, but ample material is on hand for the work.
>
> The company carried immense reserves of sulphur above ground, so that there will be no interruption in the manufacture of sulphuric acid and other necessary war materials. This reserve pile of the Union Sulphur Co. measures 800 ft. in length by 200 ft. in width, 40 ft. high, and represents about 15 months' mining.
>
> The plant of the Freeport Sulphur Co. at Freeport, Tex., is producing its normal tonnage and has a considerable reserve above ground. While the damage to the Union Sulphur Co. is unfortunate, especially at this time when sulphuric is being produced in such enormous quantities, the reserve stock situation is such that there is no cause for worry. The Union Sulphur Co.'s operatives are working day and night in the rebuilding of their plant. The sulphur is melted in the ground by steam and hot water and forced to the surface through wells where the molten sulphur solidifies on exposure to the air. The sulphur deposit underlies a bed of quicksand through which it is impossible to drive shafts and mine in the ordinary way. The development of this project is one of the interesting mechanical and chemical achievements of the past decade and, together with the Freeport Co.'s developments, makes the United States by far the greatest producer of sulphur.
>
> There are two other known deposits which can be quickly opened up in case of necessity. Work is now progressing on the development of one of these deposits.

Our own information (and we are quite satisfied as to its authenticity and reliability) is to the effect that the hurricane of Aug. 6 did a good deal of damage, which was not at all serious. Shipments by the Union Sulphur Co. were held up for four days, but on Aug. 10 were resumed and since then have been proceeding normally. The producing wells were interfered with temporarily, owing to the derricks being thrown down; but this will all be cleared up by the end of August, or a few days later. The boiler houses were damaged to the extent of having the corrugated iron roofs blown off and the smokestacks blown down; but this was all light stuff and quickly replaced.

Slacker Committees Among Coal Miners, where the men themselves keep tabs on their fellow workers who take days off without legitimate excuse, are described by president Loomis of the Lehigh Valley Coal Co. Gigantic thermometers are being erected near the entrance to each colliery, showing the tonnage produced each day, compared with its best record, and alongside are posted the names of absentees, with an estimate of what the tonnage would have been if they had all put in a full day's work.

Editorials

Our Sulphur Supply

WE TALK about the Government having certain opinions, certain policies, etc., and we think of the GOVERNMENT in capital letters. It is a convenient, and usually a conclusive, phrase to use. The Government thinks this, the Government wants that, the Government orders so and so, and that ends inquiry, discussion, or criticism. The magic word of "Government" is all-sufficient.

But when one branch of the Government says one thing, and another branch says another thing, what is the wayfarer going to do? The Fuel Administration and the Federal Trade Commission are notoriously at odds. The War Industries Board quarrels with, or at least differs from, a famous circle of other bureaus. One bureau says that there is a dangerous shortage of platinum; while another bureau says not so. One bureau becomes hysterical over the prospective scarcity of sulphuric acid, while another pronounces that the supply of that essential commodity is adequate. Are we to be misunderstood for being contemptuous of the half-baked inexpert expressions of opinion that too often emanate from Washington as the representations of the Government?

Sulphuric acid is the great basic commodity of the chemical industry. It is of basic importance in the manufacture of explosives. If we did not possess an adequate supply of sulphuric acid, our military operations would be seriously crippled. Considering this, some of the bureaus in Washington became greatly exercised over the matter of sulphuric-acid supply. Astounding estimates of the quantity of sulphuric acid required were published. The exclusion of Spanish pyrites by the War Trade Board in order to save shipping was regarded as a calamity. Commissions were appointed to investigate domestic resources of pyrites (which, of course, was a proper thing to do). The necessity of stimulating the exploitation of previously unprofitable pyrites mines was one of the main inspirations of the bill for a mines administration, with an appropriation of $50,000,000, that is still pending before Congress.

We could never work ourselves into excitement over the supposedly desperate situation with regard to sulphuric acid, but heretofore we have been unable to discuss this matter, lest we should violate a confidence. However, inasmuch as William G. Woolfolk, the sulphur expert of the War Industries Board, has himself disclosed the key to the situation that has existed all along, we are naturally released. The key has been that there is above ground, and has been all along, at the mines in Louisiana and Texas, over 1,000,000 tons of brimstone. According to Mr. Woolfolk, the present consumption of brimstone is approximately 120,000 tons a month; wherefore the existing stock is sufficient for eight months to come, even if production should be suspended entirely, which is scarcely conceivable. Mr. Woolfolk is, therefore, of the opinion that there has not been occasion for alarm over the alleged small supply of sulphur in this country. On this subject we may usefully quote from the following report by W. R. Ingalls to the Senate's Committee on Mines and Mining:

An increased requirement for sulphuric acid and a necessary reduction in the importation of pyrites from Spain have created a deficiency in the supply of this important mineral; but the tension in the situation is probably overestimated and natural factors are applying the true correctives.

In Louisiana and Texas we possess the greatest deposits of sulphur (brimstone) in the world, exploitation of which has heretofore been limited more by inability to market the product than anything else. Without any doubt, the supply can be increased immensely. The matter of sulphuric acid is perhaps the most complex of these problems. The United States possesses ample sources of sulphur, but the great resources are remote from the places where the sulphur is mainly needed, and both utilization and transportation difficulties stand in the way. Spanish pyrites come cheaply to places where there are acid works and local channels of acid consumption. The utilization of the enormous quantity of sulphurous gas that is dispersed daily into the atmosphere at Anaconda, Mont., for example, would necessitate a stupendous outlay for manufacturing plant, for tank-cars and for transportation.

The production of sulphuric acid in terms of monohydrate (H_2SO_4) in 1917 was about 4,300,000 tons, against about 3,900,000 in 1916. The Government estimates a requirement of 5,000,000 to 5,600,000 tons. We imported from Spain about 833,000 short tons of pyrites in 1917, which may be reckoned as making about 1,000,000 tons of sulphuric acid (monohydrate). If, therefore, we are to require as much acid as the Government's maximum estimate, stupendous though it be, and if we were not to import any pyrites from Spain, we would have to find raw materials for about 2,300,000 tons of acid. Although that is a very large figure, the situation as to brimstone, which perhaps ought not to be divulged, is of such a nature as to dispel any alarm. Moreover, importations of pyrites will not be checked entirely; the domestic production of pyrites is increasing; and smelters are adding to their production of acid as a byproduct; wherefore it need not be assumed that new sources for 2,300,000 tons of acid must be found. In 1915-16, sulphuric acid of 60° B., which in pre-war times realized about $6@8 per ton, sold at $50@60 per ton. Before the end of 1916 the price had receded practically to the pre-war normal. Referring to this subject, the *Engineering and Mining Journal* remarked, Nov. 18, 1916, that: "One of the war commodities that has come down to earth is sulphuric acid. In the acute period this fetched $50@60 per ton. Ordinary tower acid is now down to about $7@8 per ton, which is only a trifle in excess of what it used to be in normal times. The explanation is increased production. The consumption is still very large."

The price of $7@8 per ton at that time was undoubtedly sub-normal, considering increased cost of production. At the beginning of 1917 the market was $12@13, and even that was regarded as low. It advanced during 1917, and was quoted at $22@25 at the close of the year. The recent price in the open market has been about $25, but the War Industries Board has arranged for Government requirements at $18.

Officials in Washington talked about a sulphuric-acid requirement of about 9,000,000 tons per annum, which

looked staggering in comparison with all previous productions. The look was different, however, when it developed that it was chamber acid, containing only about 62% of H_2SO_4, that was being talked about. Sulphuric acid is produced in four common forms, viz., chamber acid, tower acid (containing about 77.5% H_2SO_4), acid of 66° B. (containing about 93.5% H_2SO_4), and strong acid, containing 96 to 98%. The only safe statistical basis is the monohydrate (H_2SO_4). Reduced to that basis, 9,000,000 tons of chamber acid becomes about 5,600,000 tons.

The results of the hurricane in Louisiana on Aug. 6 were not such as to lead to an alteration of the views expressed in this article. The controversy among several bureaus of the Government is described in detail elsewhere in this issue.

Anaconda Shows Its Nerve

SPEAKING at a mass meeting in Butte, on July 25, held in honor of the visit of John D. Ryan, president of the Anaconda Copper Mining Co., and Major-General Kenley, commander of the American air forces at home and abroad, C. F. Kelley, vice president of Anaconda, said that on that very afternoon he had been served with a demand from the I. W. W. that wages of Anaconda's employees be advanced to a minimum of $6 per day, men to be lowered and hoisted on the company's time, and calling for abolition of the rustling system and recognition of the I. W. W. If these demands were not granted by the following Saturday, there was threatened a general strike.

This announcement caused a wave of indignation to sweep through the meeting. There was a roar of applause when Mr. Kelley said:

"They don't have to wait until Saturday. They have their answer right now. The demand will not be granted. The company I represent and other operating companies in Butte will listen to any request from organized labor, but we will not deal with or recognize the 'wobblies.'"

This was the straight, bold reply that excites admiration. When the Government arranged with the producers for the 23½c. price for copper, last September, Anaconda, along with the others, agreed not to reduce wages, although they were then on the 26c. basis. When on July 2, 1918, the Government raised the price for copper to 26c., Anaconda voluntarily raised wages to the extent that, after allowing for increased freight rates, the company itself received practically no benefit from the advance. The copper producers are doing their utmost to maintain the output of copper, but are unable to equal the rate of 1917, or to supply all the requirements. For any body of men to talk or think strike in this juncture is scarcely short of treason.

Mr. Kitchin Disregards Mr. McAdoo

IT IS a fair question whether Mr. Kitchin wants to help his country win the war, or whether he merely desires to take advantage of the opportunity to punish the wealthy. Mr. McAdoo, who may be fairly regarded as representing the Administration, advises and protests in vain against the depressing plans of Mr. Kitchin, and so does Secretary Lane. The latter points out the great interest of the Administration in maintaining and increasing mineral supplies, for the purpose of which new capital must be invested, and asks properly how anybody is to be expected to invest capital for this or any other purpose if it is going to be confiscated promptly by taxation.

The bill that has finally been framed by Mr. Kitchin pays scant attention to the recommendations and wishes of Mr. McAdoo. Fortunately the Senate will have a lot to say about the matter, but unfortunately the delay in passing this legislation will have an adverse effect upon the forthcoming Liberty Loan flotation. Mr. Kitchin is to be regarded as one of the liabilities of the Administration, rather than as one of its assets.

BY THE WAY

Mining Camp Hygiene

Dave Foley, for 30 years chief of police for the companies operating the iron mines on the Michigan peninsula and in northern Minnesota, had a rare fund of personal experiences, but, being about as garrulous as a ton of iron ore, he had to be approached with great caution, reminisced R. H. Little in the *Chicago Herald*. If the listener had patience enough, the moment would come when Mr. Foley, his face lighting up with animation, would tell a story. Such a moment arrived on one occasion, and the buzz of conversation quieted down as it became apparent that Dave Foley was suddenly moved to talk. His face lighted up as he said:

"And have ye ever heard of the time we put the lads in the biggest bunkhouse on the range into nightgowns? There wuz four hundred of the lads in this wan big bunkhouse. They wuz mostly Monteniggers an' Croastians an' Maltese, with here and there a Finn an' a Wap. The cumpany had the idee of lettin' 'em live their own ways in th' bunkhouse, an' each divil had a bunk, in which he slept and where he always kept a blanket an' a shirt an' three er four yards of sausage an' a couple o' bottles o' beer an' half a cord of black bread an' a bushel of garlic. When they turned in fer the night they jest crawled in, clothes, boots an' all, with th' beer an' the sausage an' the garlic.

"But wan day an officer of the cumpany comes out from Pittsburgh, or one of them seaport towns in the East, an' he takes one look at the bunkhouse, and they carried him out in a dead faint. We had no pulmotor in them days, but we gave him all the fresh air on the Mesabi range, an' burnt a rag under the nose of him an' sent all the way to Hibbing fer a bottle of o' de cologne out of the barber shop to sprinkle on his face.

"When he comes to he goes to the office an' he says a few things, an' then the superintendent sends fer me an' he says: 'Foley,' he says, ''tis a new order. The men cannot sleep in their office clothes any more at all, an' they must be taught that 'tis unconstitutional in the land of the free an' the home of the brave fer to go ter bed with their muddy boots still fastened tite on the feet of 'em. An' they must get over the foreign habit of sleepin' on top of th' groceries, Foley. Let the garlic an' the sausages be kept elsewhere. And

Foley,' says he, rather shamed-face-like, 'I must tell ye, furthermore, that the order is that the men from now on and forever more shall wear becoming nightgowns when they retire to their rest each an' every night. That's all, Foley.'

"'An' after I git the heathen into their little white nighties,' I says. 'Do I listen to them sayin' their prayers an' thin tuck 'em in bed and kiss 'em good night?'

"'You can suit yourself as to that,' says the superintendent, 'but get 'em into their nighties.'

"'Twas a fine job that was picked out fer me. I paraded the divils at noon an' talks to thim with the interpreters all jabberin' after me that which I was sayin' every time I stopped for breath.

"'Men,' says I, ''tis a Christian country you are in,' says I, 'an' ye will become citizens as soon as you show enough intelligence to put the ballot that is placed within yer hand into the ballot box. But no man can become a citizen of the United States except he takes his pants an' his onion soot an' his boots offen him at nite and wears a nightie. You are hereby ordered to buy nighties an' to sleep in th' same as well. Those of you that refuse to become Christians can get yer time from the offis an' beat it off the range.'

"They yelled blue murder in 25 different languiges an' made a break for the offis for their pay. An' thin they thought it over an' sed they would stand for the nighties, an' I assessed each man 50 cints fer a night shirt. I sent a polisman to raid all th' towns on the range an' buy four hundred night shirts. He got 'em, an' that night come bedtime I marched in with ten of the mining company police, all carryin' fine, long clubs fer the purpose of skiddin' the terriers out of their clothes an' sliding 'em into the nighties.

"'Twas a busy night, but finally the job wuz done an' each an' every man was sittin' on the edge of his boonk saying horrible things in a furrin languige, but every man Jack of 'em was fairly radiant in his cute little nightie.

"You shud have seen 'em. There wuz about only 50 he-nighties to be found in th' stores, an' so the man I sent to buy 'em had filled out the order with ladies' nightgowns an' dressing jackets that was all frills an' soft laces an' blue and pink ribbons forninst them. Ah, 'twas a sight of a lifetime. But a week it took before we could persuade 'em to git into their nighties without threatenin' 'em with an ax. Every night after that after the men had crawled into their boonks we would make the grand rounds to see that ivery man hed on his nightie. An' there was many to point out thim that had put their nighties on over their coat an' pants because they wanted to see us haul 'em out. And every man we wud catch who had tried to deceive we wud rap briskly on the feet of him with a poplar club. 'Come out, ye stiff-necked polar bear,' I wud say, 'skin off yer clothes an' yer onion soot an' climb inter yer little lace nightie like a citizen of the United States. 'Tis the law of the land!'

"But after awhile they got used to the nighties, an' very proud of them, too, did they get, an' they took to wearing 'em on Sunday the same as you would a dress suit an' a silk hat. An' when new immigrants arrived they wouldn't let 'em into the bunkhouses unless they cud show a proper nightie."

Edward Dyer Peters

We abstract the following from a biography of the late Edward Dyer Peters by Eleanor Bradley Peters, recently published:

Extract from a Colorado paper 1870 or 1871:

Middle Boulder: Silver Bullion Shipments. The first two shipments of silver from A. D. Breed's new reduction works at Middle Boulder were made within the past five days. The first of these embraced 400 lb., and the last 6200 oz. of silver, in bars, the product of ore from the Caribou mine. The bullion has been forwarded to New York . . . . Under the skillful management of such competent millmen as Charles E. Sherman and E. D. Peters, this mill will henceforth be found all that could be desired and will take the lead in Colorado in the production of silver bullion.

From another Colorado paper of a little later date (1872):

A Good Appointment: Edward D. Peters, a young man of rare abilities and acquirements, and who has few equals, theoretically or practically, in mining and milling, has been appointed and confirmed territorial assayer for the southern district of Colorado, the office being located at Fairplay, Park County. At present Mr. Peters is engaged at A. D. Breed's reduction works, at Middle Boulder, as assayer. We congratulate him upon his appointment, and the people of the South in obtaining the services of so thorough and correct a metallurgist.

His first contributions to the *Engineering and Mining Journal* were made at this time, while he was assayer at the first Caribou Silver Mill, in Boulder County, when he sent some brief notices, on milling results, to Dr. Raymond.

From July, 1871, to March, 1872, he was superintendent and metallurgist of the largest silver mine in the country (the Caribou), which position he resigned, having received an appointment in February, 1872, from the Governor of the Territory, as territorial assayer for the southern part of Colorado. In the fall of the same year he built the Mount Lincoln smelting works. He writes from Dudley, Feb. 1, 1873:

It is a beautiful winter's morning, and I can hardly realize that I am in the center of the Rocky Mountains almost 11,000 ft. above you. My office is in a little flat, surrounded by thick pine forests, and just at the very foot of the highest peak in this whole range from British America to Mexico. The ground commences rising from my very doorstep, and, in the course of one-eighth of a mile, becomes so steep that only the little Mexican jack can be used to pack up provisions and supplies to our mines, which are situated almost on the summit of the highest peaks. As the snow lies some five feet in the timber on the mountain sides, even they are useless now, and are down on a rancho, in the valley, some 50 miles from here, dying as fast as they can, from the epizoötic. We have lost some 40 in the last month, and all the horses have it so badly that we only get our mails from Denver every two or three weeks, brought up by bull-teams. The smelting furnace, which I built last fall, and for which I imagine that I have the same sort of affection that a mother has for a pet child, is running finely, without any delays or drawbacks, and is building me up quite a reputation throughout the territory. When I came here I was simply "Professor" or "Captain" (every man has a title out here, you know). When the furnace started up successfully I was at once dubbed "Major," and since then have usually been addressed as "Colonel." I expect a Brevet Generalship shortly, as promotion is rapid in this country, but if I should ever make a failure it would not take long to degrade me to the ranks. However, I am not afraid of that. The ores are easily treated. There is a fascination in the business that I am engaged in that you will not appreciate. It is certainly a pleasant trade to take the muddy ore from the mines, to determine its exact value and pay for it, to put it through the different furnaces, and finally bring out the gold, silver, copper and lead, and, above all, to have the products agree exactly with the amount that you promised beforehand. There is a touch of old alchemist's mysteries about it which renders it always new and interesting, and one feels every day that he is not only adding to the material wealth of the world, but is also filling his own mind and pocket.

In November, 1874, he returned to the East. Mining was at that time in a very low state; the ores in Colorado were supposed to be worked out, and Peters gave up all hope of continuing in his chosen profession.

"The Rocky Mountain Canary," as the burro is called there, is an important link in the war organization in France, which at present is impressing itself so strongly upon the German consciousness, says the *Sun*. He is lending his strength to the Entente as a bearer of materials to fields of battle to which the motor truck and the horse cannot penetrate.

Patient beyond praise, uncannily surefooted, reflective, slow but certain, and indifferent to the enemy's shell fire, the burro is making himself a name in the line. He has made a record in France by his ability to go anywhere and his phlegmatic indifference to fire.

Personals

Have You Contributed to the Association of the 27th Engineers?

Ernest Hibbert is with the British America Nickel Corp., at Sudbury, Ontario.

Harry J. Wolf examined silver-lead properties near Georgetown, Colo., recently.

H. C. Bellinger, general manager of the Chile Exploration Co., has recently returned from Chile.

S. Ford Eaton, of the Guomoco Mining Co., Simiti, Colombia, expects to be in New York in October.

G. L. Sheldon, of Ely, Nev., is doing examination work in Beaverhead County, Montana, and has headquarters at Dillon.

George Ridgway has retired from the management of the Lancefield mine, Beira, West Australia. He has been succeeded by **A. E. Faul.**

L. W. Trumbull, state geologist of Wyoming, recently spent a week in Beaverhead County, Montana, examining the various oil fields.

Samuel W. Cohen has returned to Montreal after a month's tour of inspection of mining properties in Northern Ontario, Nevada and Colorado.

A. G. Mackenzie, secretary of the Utah section of the American Mining Congress, is in Washington in the interest of mining in the intermountain region.

George A. Packard has returned to his office at 50 Congress St., Boston, Mass., after having been absent on consulting work in the West for five months.

Prof. R. C. Wallace, head of the department of geology and metallurgy, University of Manitoba, has been appointed mining commissioner of Northern Manitoba.

Sergio Bagnara, metallurgist of the St. Joseph Lead Co. of Bonne Terre, Mo., is on his way to Washington, having been appointed metallurgical engineer to the Ordnance Department.

Richard Hamilton has been elected president of the Chamber of Mines of Western Australia, for the twentieth year. **G. M. Roberts** has been elected a vice-president, vice **R. B. Nicolson,** deceased.

D. D. Conduit and **F. W. Reeves,** of the U. S. Geological Survey, have recently been in the Dillon, Mont., section, studying oil possibilities and in particular examining oil shales, of which samples were taken.

Forest Rutherford, consulting engineer, is in Colorado making an examination of some large mining properties, and while there will attend the Colorado meeting of the American Institute of Mining Engineers.

E. J. Mehren, editor of "Engineering News-Record," and **Floyd W. Parsons,** editor of "Coal Age," will attend the Colorado meeting of the American Institute of Mining Engineers during the coming week.

S. F. Shaw is making a trip of inspection to the Monclova, Reforma and Bonanza units of the American Smelting and Refining Co., after which Mexican headquarters will be at Charcas, San Luis Potosi.

Prof. Theodore Simons, of the Montana State School of Mines, has returned to Butte from a two-weeks' visit to Philipsburg, Mont., where he investigated the manganese mining and milling problems of the district for the U. S. Bureau of Mines.

Walter Harvey Weed recently returned from the West after several months' absence from New York and left again to examine a lead-zinc property in Quebec on Aug. 25. He will therefore be unable to attend the Colorado meeting of the American Institute of Mining Engineers.

Forrest B. Caldwell, of the California State Bureau of Mines, has arrived at Medford, Calif., as the reprensentative of the U. S. Bureau of Mines, to examine the chrome deposits in Jackson County, after having completed a similar survey in Siskiyou County.

Percy E. Barbour, formerly managing editor of the "Journal," has been appointed a Captain in the U. S. Engineers, and is awaiting assignment. Mr. Barbour left the "Journal" to become Deputy Superintendent of the New York State Troopers, from which organization he has received a leave of absence for the period of the war.

Miss Helen E. Guyer, of Boston, has been appointed chief clerk of the Tucson station of the U. S. Bureau of Mines. This is the first time that such a position has been awarded to a woman. Miss Guyer was formerly an assistant in the chemical division of the University of Illinois. She joined the Bureau of Mines force in 1916.

Capt. Curtis W. McGraw, a son of James H. McGraw, president of the McGraw-Hill Co., Inc., has been wounded in France by a shell fragment and is now convalescent in a British military hospital near London. Captain McGraw is a graduate of the 1917 Plattsburg Camp and was commissioned in August of last year. He has two brothers in the service.

James Colquohoun, for many years in charge of the Arizona Copper Co.'s mines at Clifton, Ariz., is thought to have been lost in the general disorder that has followed the rise of the Russian Bolsheviki. He left Arizona to develop copper deposits in the Caucasus mountains. Latterly he is understood to have been operating in the oil fields of the Batum district of southeastern European Russia. Mrs. Colquohoun has received no word from her husband for the last five months. One of her two sons, both born in Clifton, was killed in a Scottish regiment during the first few months of the war. The second is with the British forces in France.

Obituary

Earl G. Austin, an American mine foreman employed at Nacozari, Son., Mex., died on Aug. 13 from wounds inflicted by three Mexicans whom he had refused to promote from muckers to timbermen. He was buried in Colorado Springs.

N. Bruce MacKelvie, president of the Butte & Superior Mining Co., was drowned on Aug. 17, while bathing near his estate at Port Washington, N. Y., due to a stroke of apoplexy. Mr. MacKelvie was 39 years old. He was connected with the brokerage firm of Hayden, Stone & Co., of New York, and was a director in various other corporations.

Societies

Chemical Alliance, Inc. The committee on acids has called a meeting of all members of the acids section at the Hotel Traymore, Atlantic City, N. J., on Sept. 6 at 2.30 p. m. All members of the fertilizer section who are producers of sulphuric acid have been notified to be present.

Northwest Mining Association has decided to call an international conference to discuss the gold problem and suggest methods to aid production. All in northwestern states and British Columbia have been invited to attend. Special invitations have been sent to the Minister of Mines and Minister of Finance for British Columbia.

Engineers' Club of Northern Minnesota visited the mines of the Cuyuna range on Aug. 23 and 24. The members left Hibbing on Aug. 22 in automobiles for Grand Rapids, Minn., where supper was served. Starting anew, they reached Crosby, Minn., on the evening of Aug. 23. The following day was spent in visiting the mines near Crosby.

American Institute of Mining Engineers, New York Section. The following will attend the Colorado meeting of the Institute during the coming week: Sidney J. Jennings, Herman Garlichs, C. S. Witherell, W. R. Ingalls, Bradley Stoughton, J. I. Thompson, D. J. McAdams, Jr., J. Malcolm Muir and guest, Mr. and Mrs. H. N. Eavenson, Mr. and Mrs. C. Kemble Baldwin, Mr. and Mrs. A. T. Hyde, Mr. and Mrs. Rudolf Gahl, and Mr. and Mrs. George D. Barron.

Duluth Engineers' Club. Following the first meeting on May 20 at the Kitchi Gammi Club, Duluth, Minn., at which the question of organizing a club was discussed, the committee of Duluth engineers called another meeting on Aug. 5 and held a dinner at which Alfred D. Flinn, secretary of Engineering Council, was a guest. Mr. Flinn delivered an address upon the "Centralized Activities of National Engineering Societies." The committee submitted articles of incorporation, which were adopted with minor changes. The following officers were elected: W. G. Swart, president; E. R. Lewis, first vice president; W. N. Ryerson, second vice president; W. H. Woodbury, secretary; W. H. Gallagher, treasurer; F. E. House, T. W. Hugo, W. F. Scawedes and F. E. Downing, directors. Efforts are now being made further to develop the organization in which it is planned to include all who can properly be classed as engineers. The highest professional standard is desired that is consistent with broad-minded democracy.

Trade Catalogs

Taber Rotary Pumps. Taber Pump Co., Buffalo, N. Y. Catalog No. 14; pp. 80; 6¾ x 9¼; illustrated.

Conduit Fittings, Etc. Steel City Electric Co., Pittsburgh, Penn. Catalog No. 33; pp. 108; 6 x 9; illustrated.

Electric Grab-Bucket Hoists. Sprague Electric Works of General Electric Co., New York. Bulletin No. 48,938, superseding No. 902; pp. 24; 8 x 10½; illustrated.

Internal Combustion Locomotives is the title of Record No. 85, issued by the Baldwin Locomotive Works, Philadelphia, Penn., and dealing with gasoline locomotives of a number of sizes and classes. Pp. 32; 9 x 6 in.; illustrated.

Transformers. General Electric Co., Schenectady, N. Y. Bulletin No. 45,203; pp. 4; 8 x 10½; illustrated. Describes the construction and equipment of type H, form KDD, circular coil transformers, oil insulated and self- or water-cooled, made in medium sizes for moderate voltages.

Industrial News

Chicago Pneumatic Tool Co. announces that the contract has been let and work started on the erection of an up-to-date addition to its Cleveland plant, which is planned to double the present output. It is expected that work will be completed on the building itself about Nov. 1 and that the additional production contemplated will be available very soon thereafter. The company has appointed **C. W. Cross** as special representative for the sale of pneumatic tools to railroads, vice **L. C. Sprague,** promoted to be district manager of sales for the company at New York.

New Patents

United States patent specification listed below may be obtained from "The Engineering and Mining Journal" at 25c. each. British patents are supplied at 40c. each.

Mine Hoists, Interlocking Control For. Charles L. Perry, Schenectady, N. Y., assignor to General Electric Co. (U. S. No. 1,273,661; July 23, 1918.)

Sulphur from Pyritic Material, Process of Recovering. Addison F. Hoffman, Pittsburgh, Penn. (U. S. No. 1,273,370; July 23, 1918.)

Nickel from Nickel-Copper Alloys, Method of Separating. Joseph Dhavernas, New Brunswick, N. J., assignor to United States Nickel Co., New Brunswick, N. J. (U. S. No. 1,273,465; July 23, 1918).

Cerium, Process for Making Metallic. Alcan Hirsch and Marx Hirsch, New York, N. Y., assignors to Alpha Manufacturing Co. (U. S. No. 1,273,223; July 23, 1918.)

Ore-Separator. Frank Gottfried Schmidt, San Jose, Calif. (U. S. No. 1,272,125; July 9, 1918.)

Concentrator, Dry. August B. Emery, Messina, North Transvaal, South Africa. (U. S. No. 1,272,642; July 16, 1918)

Magnesium Oxide from Dolomite, Process for Obtaining. Ardon M. Mitchell, Tuckahoe, N. Y., assignor to Mitchell & Grenelle, Inc., New York, N. Y. (U. S. No. 1,273,110; July 16, 1918)

Silver, Preparation of Proteid. Yutaka Nukada, Tokyo, Japan. (U. S. No. 1,272,987; July 16, 1918)

Specific-Gravity Scale. Christopher A. Becker, West Nutley, N. J., assignor to the Torsion Balance Company, New York. (U. S. No. 1,272,605; July 9, 1918)

Titanium Oxide Concentrate and Method for Obtaining Same. Auguste J. Rossi, Niagara Falls, N. Y., assignor to the Titanium Alloy Manufacturing Co., New York, N. Y. (U. S. No. 1,272,855; July 16, 1918)

Tube-Mill Feeder. Harry W. Hardinge, New York, N. Y. (U. S. No. 1,272,801; July 16, 1918)

Editorial Correspondence

SAN FRANCISCO—Aug. 21

The Second Annual Report of the Pan-American Petroleum and Transport Co. for the year ended Dec. 31, 1917 shows net earnings applicable to dividends on common stock amounting to $3,536,728, an equivalent to $5.80 per share on 609,895 shares, outstanding, of $50 per share par value. Gross income from operations for the year amounted to $4,512,649. Only $401,372 of this total was received from operation of oil properties. The revenue derived from steamships amounted to $4,111,278. The company now has 18 ships afloat, of an aggregate carrying capacity of 145,965 tons. Five ships are under construction, of an aggregate carrying capacity of 28,305 tons.

Road Construction for Transportation of chrome ores in Siskiyou County is receiving Government aid through the Forestry Service and at the suggestion of Albert Burch, of San Francisco, representing the War Industries Board. The advice of Congressman Raker as to the part the Government would assume in the undertaking makes it appear that a sum of $97,000 will be expended in road construction and that Siskiyou County had contributed $10,000 of this amount; the inference following that the Government will provide the remaining $87,000, which would be ridiculous if true. The facts are that through the Forestry Service the Government has appropriated $10,000 and the County of Siskiyou $10,000, making a total of $20,000 to be expended under the direction of the Department of Agriculture. The chrome producers have agreed to contribute at the rate of 4c. per ton mile, or a maximum of $2 a ton, toward the maintenance of the roads.

Gold Production in California in 1918 will probably be 20 or 25% lower than in 1917. This falling off is due, of course, to high costs of mining, delay in receiving supplies and materials, diminution in labor and the decreased efficiency of labor. There has been practically no new investment in gold-mining properties so far, and it is not likely that whatever relief may come from the Government will be effective early enough to encourage renewed investment and development of new ground before 1919. The remedy of the present evil suggested by the conference of Aug. 12-14, that the Government provide a bonus for gold production, does not meet the approval of most of the large producers. The disavowal of intention to place a premium on gold with which the resolutions of the conference were concluded may, in theory, mean just what the conference meant to express; but in its practical application a bonus amounts to the same thing as a premium. And so far as any actual relief to the gold miners is concerned, the thoughtful and conservative gold producers of California believe the plan to be impracticable and without merit of serious consideration. It would no doubt be a scheme of great prospective prosperity for the promoter and stockseller.

DENVER—Aug. 20

Cripple Creek Gold Production is being maintained at its normal level of about $1,000,000 monthly, in spite of adverse conditions in the form of increased cost of all mining supplies and increased freight rates. Present prospects are that the production will be kept up to normal during the war, but it will probably be increased after the war when a downward adjustment in cost of labor and supplies may be expected.

Manganese Ore is available in large quantities in the Leadville district, but the mining outlook is not encouraging, on account of the uncertainties of the future caused by war conditions. Most of the ore available requires careful handling, and the margin of profit is small. If the current market price of the metal drops a few points the shipper faces a loss. It is probable that shipments of this ore will decrease on account of the 25% increase in freight rates, unless a corresponding increase in market price is allowed.

A Bonus on Gold was one of the chief subjects discussed at the recent meeting of the Colorado Metal Mining Association and the Colorado Chapter of the American Mining Congress held in Denver. Resolutions were adopted calling attention to the deplorable situation of the gold mining industry. In resolutions it was pointed out that owing to the rapidly increasing cost of labor and supplies in gold mining operations, with the value of gold at a stationary level, most of the larger low grade and virtually all of the smaller gold mines cannot be operated at a profit. Attention also is called to the important fact that our war operations must be financed on a gold basis of credit, and that the production of gold should be maintained and increased. With such conditions prevailing the mining men resolved that it was the sense of the meeting that of the various relief measures proposed, the following will be most effective in stimulating and maintaining the production of gold in the United States: "Purchase by the United States Treasury of all gold newly produced from mines in the United States and its dependencies at a price sufficient to cover the increased cost of production since July, 1914, adequate provision being made that all amounts over and above the standard price of $20.67 per ounce shall accrue to the benefit of the companies or individuals who produce the ores or mill products from which the gold is derived, and no part of such amounts shall be absorbed by increased charges for smelting, milling, refining, or freight."

SALT LAKE CITY—Aug. 23

Increased Wages for Shaftmen demanded in the Tintic district, would raise the pay for this class of work to $7 per day. This wage as fixed by the Tintic District Miners' Union, will amount to $1.75 more per day than the wage of the ordinary miner in Tintic, which is $5.25 per day. It has been the custom at Tintic to pay 50c. a day more for shaft work than the ordinary miner received. The effect of this demand on undertakings where shaft work is needed can easily be imagined. The case in point is the new shaft of the Chief Consolidated Company. At the beginning of this work the men received $6.50 a day, and when they struck for more pay, new men were put on. Then followed the action of the Tintic District Miners' Union, which passed a resolution fixing the wage at $7 a day.

Utah Chapter of American Mining Congress received the following telegram on Aug. 3 from secretary A. G. Mackenzie, which embodies the reply of Secretary of Labor W. B. Wilson to the telegram sent by the chapter on July 29.: "Have just finished interview with Secretary of Labor Wilson and Felix Frankfurter, Assistant Secretary of Labor and Chairman of the War Policies Board, at which your telegram of July 29 was presented by me. After reading your message and discussing the Utah situation, Secretary Wilson asked me to give you his definite assurance that no attempt to establish fixed scales would be undertaken until after all interests concerned had been freely consulted and had an opportunity to present suggestions and criticisms of any plan offered. He said he appreciated some of the difficulties under which Utah metal producers are now operating and that his department, although anxious to reduce as soon as possible the economic waste resultant from labor drifting from place to place, is also anxious not to take any action that would force any properties to suspend operations. He said local conditions should be fully recognized in any wage-stabilization plan undertaken and asked me to assure you that he does not favor the suggestion to establish a uniform zone scale and leave adjustments until later, as he recognizes that such a program would be very likely to lead to disturbances."

Preliminary Figures of Utah Production for 1917 compiled by the U. S. Geological Survey show the value of the output to have been $99,328,000, holding the record, in spite of higher costs than in 1916, shortage of labor, smelter embargoes, and exceptionally severe weather during a large part of the winter. Also the prices obtained for metals except in the case of silver, were not as high as in 1916. The gold output for the year amounted to $3,355,156, and the silver output to 13,479,133 fine oz. Copper produced was 246,674,153 lb., of a value of $67,342,044; lead, 178,521,958 lb., of a value of $15,352,888; and zinc, 21,286,871 lb., this being slightly less than the 1916 production. Comparing production during the latter half of 1917 with production during the first part of the present year, it appears that Beaver County and Park City have been making increased shipments, and that less ore has been coming in from Bingham and Tintic, the latter district showing a decrease to about 28,000 tons a month. Park City production has this year been at the rate of about 9000 tons monthly. Of the total output of the state, Bingham produced 75 per cent. Production by Utah Copper during the first quarter of 1918 was slightly less than in 1917, though in April and May there was improvement. The new leaching plant of this company—in part in the experimental stage—is treating 1500 tons of low-grade carbonate ores, and may add much to the copper output of the state. The Ohio Copper company is expected to show increased production in 1918. On the whole, great increase in the copper production of the state in 1918 is predicted. Most of the lead produced by the state comes from Bingham. Here there has been no increase in the output of that metal. The increase in lead production by Park City may make good the decrease on the part of the Tintic district. The Tintic Standard in the eastern part of the Tintic district, is making good shipments of lead-silver ore. In regard to the production of zinc, an increase during 1918 is not expected.

CALUMET, MICH.—Aug. 21

Constant Demand for Lake Tonnage continues at Portage Lake and Torch Lake ports to handle consignments of refined copper for the East. Boats are loading every week at Hubbell, Houghton, Hancock and Dollar Bay, and several cargoes have already gone East by the Lake route this season. The Lake shipments of copper can be continued well into November and perhaps up till December 1.

DULUTH, MINN.—Aug. 22.

Organized Assessment Districts of St. Louis County will practically double the valuation of mining lands within their borders as a basis for 1919 taxation, according to assessors. Mines which have been valued at $1,000,000 on the basis of 50% of the true value will probably be put up to $2,000,000, and others will follow the same scale. As the bulk of the income of all the districts along the Mesabi and Vermilion ranges is derived from ore lands and mining properties, both above and below the ground, it is evident that the incomes of each district, including organized towns, cities and villages, will be greatly increased next year unless steps are taken to lower the tax rate accordingly.

The Oliver Iron Mining Co. has been made defendant in three suits filed in the district court, the total amount of damages sought being $215,305.10. Plaintiffs are the Leon Investment Co., which asks $142,264.64; the Higgins Co., which claims that it has been damaged to the extent of $52,171.76, and the Gilbert Investment Co., which seeks to recover $20,868.70. All three allege that on Jan. 2, 1913, they possessed interests of varying proportions in the Norman mine at Virginia, and that on that date the Oliver Mining Co. entered upon an agreement with each whereby it was to continue mining the ore as heretofore, but this time under a contract which would allow certain percentages of profit to each holder of the land. The complaints allege non-payment of these profits.

TORONTO—Aug. 23

A Lignite Utilization Board, charged with carrying out the establishment of a plant for producing fuel for domestic uses by carbonizing and briquetting the lignite of Saskatchewan, has been appointed as the result of an agreement between the governments of Canada, Saskatchewan and Manitoba. The board consists of R. A. Ross, consulting engineer of Montreal, who has taken a keen interest in the problem

and is an active member of the Council for Scientific and Industrial Research; J. M. Leamy of Winnipeg, provincial electrician of Manitoba; and J. A. Sheppard, a prominent business man of Moose Jaw, Sask. In addition to producing fuel briquets it is proposed to recover important by-products, including oil, pitch, ammonia, sulphate and gas. The expenditure involved is estimated at $400,000, of which the Dominion contributes $200,000 and the provinces interested, $100,000 each.

Charged With an Infringement of the Ontario Land Surveyors Act in connection with some work he had done for the Dominion Reduction and Aladdin Cobalt mining companies, N. P. MacDonald, mining engineer of Cobalt, was given a hearing in the Cobalt police court on Aug. 21. The case involves an important point as to the respective rights of mining engineers and surveyors, the latter being the authorized technical body, qualified to make surveys for recording purposes. This point is not in question, the issue involved being the right of a mining engineer to do limited survey work: that is, surveys and measurements on ground contained within properly recorded boundaries and on privately owned property. This has been a common practice in Cobalt and Ontario and hitherto regarded as legitimate, as the technical training of mining engineers includes surveying work. The evidence of a number of mine managers and employees was heard and judgment reserved until September 11.

The Mining News

ALASKA

ALASKA SHIPMENTS of domestic copper, ore and matte to the United States during July were 9350 gross tons, having a copper content of 3,994,204 lb. and valued at $927,579.

ARIZONA

Mohave County

MOSSBACK (Kingman)—Shaft down 340 ft. and good gold ore has been cut. No drifting to be done until 500 level is reached.

STANDARD MINERALS (Kingman)—Expect to have 50-ton mill in commission by Nov. 1.

TINTIC AND MERRYBELLE (Kingman)—Hoisting plant installed at Tintic, and shaft to be sunk. Tunnel is being driven at Merrybelle.

Pima County

NEW CORNELIA (Ajo)—Good progress made in three-compartment shaft. Station cut at 250 level and drift being driven.

Pinal County

U. S. VANADIUM (Kelvin)—Five tons of vanadium concentrates shipped to Denver this week by Allied Metals Corporation. Harry S. Bryan is in charge.

ARMOUR COPPER (Price)—Is prospecting a group of claims in the Red Hill district by means of churn drills.

AJAX (Ray)—Work is to be resumed after long period of idleness. Controlling interest recently purchased at sheriff's sale by F. M. Allen of Globe. E. W. Holt will be in charge.

COPPER BUTTES (Ray)—Now being operated by old company and making regular shipments of three cars a week.

INDIAN SPRINGS (Ray)—Group owned by Joe Sherlock and Pete Schillings has been sold to Ray Broken Hills Mining Co. Group is geologically a part of the Broken Hills section and can be developed to advantage.

RAY-HERCULES (Ray)—First 500-ton unit of the 1500-ton mill in operation.

Yavapai County

BLUE MONSTER (Jerome)—Main working shaft down 280 feet.

VERDE SQUAW (Jerome)—New machinery has arrived and is being installed.

POCAHONTAS (Mayer)—Mill and a 50-ton flotation unit to be installed.

CALIFORNIA

Amador County

TREASURE (Amador City)—Good grade of ore cut in lower levels. O. H. Rohlfs is superintendent.

Del Norte County

CHROME DEPOSIT in hills near Crescent City reported by Mosely brothers.

Inyo County

CALIFORNIA SULPHUR (Talus)—Refining sulphur from deposit at Coso hot springs. Two retorts to be installed with capacity of 30 tons per day. O. B. Bachman of Los Angeles is manager.

Los Angeles County

CALIFORNIA GRAPHITE (Los Angeles)—Mill operating and shipping product.

Nevada County

CHROME DEPOSITS are being operated in Alta Hill district, formerly large gold producing region.

GRASS VALLEY CHROME (Grass Valley)—William F. Mau interests purchased by A. A. Codd, a mining engineer of Reno. Arranging to ship 140 tons mined by Mau.

COLUMBIA CONSOLIDATED (Washington)—Property to be closed temporarily. Large tonnage of ore said to be blocked out.

Riverside County

TEMESCAL TIN (Corona)—Property will be reopened and developed by New York men. Early development consisted of two 180-ft. shafts and vein followed by drifting for 300 ft. Idle many years.

Shasta County

CRESCENT COPPER (Keswick)—Good ore reported. Situated between Keswick and Shasta. John E. Baker is manager.

SEAGRAVE CHROME (Redding)—Hauling ore in wagons over new road 1½ mi., then by sled down ½-mi. incline; hauled on light trucks 4½ mi. to Noble station near Harrison Gulch. There it is loaded on large motor trucks and hauled 45 mi. to Redding and thence by rail 25 mi. to Heroult smeltery.

Sierra County

CHROME SHIPMENTS by motor trucks from Downieville, Gibsonville and other points going to Nevada City and Quincy in large amounts. High-grade ore shipped from Gold Bluff-Oxford mine to Nevada City for treatment.

Siskiyou County

CHROME ORE mined by Dr. J. F. Reddy of Medford, Ore., near Hamburg Bar will be hauled by 15 motor trucks to Hornbrook, a distance of 50 mi., over the road now being constructed and repaired by joint labor of Siskiyou County and the U. S. Department of Agriculture. Five trucks have arrived and 10 more are ordered. Hauling contract provides for handling minimum of 500 tons and maximum of 1000 tons per month.

Tuolumne County

LA GRANGE GOLD DREDGING CO. (La Grange)—Operating in Stanislaus, Stanislaus County, has purchased reservoir site at a cost of $35,000.

BELMONT-SHAWMUT (Shawmut)—Formerly known as Eagle-Shawmut. Large gold production maintained and 60-stamp mill operating regularly.

COLORADO

Custer County

PASSIFLORA (Westcliffe)—Sinking Herman shaft to 330 level.

Gilpin County

GILPIN-EUREKA (Central City)—Main shaft now down 720 ft. and 700 level is being extended on both sides of shaft. Percy R. Alsdorf is to superintend installation of flotation system in the mill. E. L. Clark is general manager.

IMPERIAL MINING (Central City)—To sink shaft at Homer mine 100 ft. further. To enlarge shaft house and make room for compressor recently purchased.

Lake County

JASON (Leadville)—Reopening and equipping old Neptune shaft.

San Juan County

SUNNYSIDE (Eureka)—Production of 600-ton mill reduced, owing to scarcity of labor.

GOLD KING (Silverton)—To remodel old 300-ton stamp mill.

HAMLET (Silverton)—Remodeling mill to install flotation unit for selective work on zinc-lead, silver and copper ore.

IDAHO

Shoshone County

SPOKANE METALS (Mullan)—New 200-ton mill in operation on tailings at Government Gulch.

OLD VETERAN (Wallace)—To drive crosscut from main drift to footwall in lower tunnel.

MICHIGAN

Copper District

BALTIC (Baltic)—Shaft No. 2, down to 19 level, providing more than half of mine output.

CALUMET & HECLA (Calumet) Steel for new flotation plant at Lake Linden in place. Plant under cover and ready for installation of machinery.

SENECA (Calumet)—Vertical shaft sunk 100 ft. during first half of August.

FRANKLIN (Demmon)—Resumed operations at mine and mill.

HANCOCK (Hancock)—Has installed electric locomotives on the two levels opened on two eastern lodes.

MAYFLOWER-OLD COLONY (Houghton)—Shaft down 550 feet.

AHMEEK (Kearsarge)—Resumed hoisting at No. 4 shaft, temporarily closed down on account of fire.

MICHIGAN (Rockland)—Accumulated considerable mass copper during August. Increased rock shipments to four cars daily.

Iron District

BARNES-HECKER (Ishpeming)—Construction of power plant commenced.

REPUBLIC (Republic)—Contract for erection of 47 x 67-ft. power plant has been let.

MISSOURI

Joplin District

DEWING (Granby)—Purchased and will erect 200-ton mill on lease south of here on site of old Valentine mine.

BANKERS (Joplin)—New 250-ton mill being erected on lease northwest of Chitwood.

MONTANA

Beaverhead County

TUCARORA (Argenta)—Two cars of ore shipped recently by H. H. French and Warren Greater.

POLARIS (Polaris)—Operating small force. Changing mill to lixiviation process.

Lincoln County

LUKENS-HAZEL (Libby)—Contemplating installation of 250-ton mill and hydroelectric power plant.

Missoula County

IRON MASK (Carter) — Has awarded contract to drive 100-ft. extension of main tunnel.

Silver Bow County

ANACONDA (Butte) — Concreting of Moonlight shaft to begin soon. Sinking Mountain View shaft. Shaft sinking in progress at Belmont and Original mines.

DAVIS-DALY (Butte)—Opened up copper-silver ore on 2300 and 2500 levels of Colorado mine.

TUOLUMNE COPPER (Butte)—Has cut new oreshoot 300 ft. east of main crosscut on 700 level, carrying good copper and silver.

NEVADA

Esmeralda County

RED HILL FLORENCE (Goldfield)—Crosscutting on 500 level and driving north on 300 level to connect with Mohawk shaft.

SILVERMINES CORPORATION (Hornsilver)—Milling plant treating over 100 tons of custom ore per day from various mines in district. Considerable activity now in evidence; several old mines have been reopened,and development work is exposing new oreshoots.

Humboldt County

PACIFIC TUNGSTEN (Winnemucca)—Closed deal for purchase of 17 tungsten-bearing claims belonging to Charles Nofsinger and L. S. Evans, of Winnemucca. Claims are located three miles south of Rose Creek. Work on large scale to commence at once; first work to be construction of boarding and bunk-houses for crew.

Lyon County

MASON VALLEY MINES (Thompson)—Regular shipments 6000 to 7000 tons weekly received at smelting plant. Bluestone, Mason Valley Co., and Nevada-Douglas are largest individual shippers.

NORTHERN LIGHT (Yerington)—Making shipments of high-grade copper ore.

Mineral County

CANDELARIA DISTRICT is showing activity and small shipments of silver ore are being made.

OLYMPIC MINES (Mina)—Mine and mill operating steadily, but at reduced tonnage on account of water shortage.

PITTSBURG-DOLORES (Rockland)—Mine and mill closed down and will probably remain so until gold mining operating conditions improve.

Nye County

UNION AMALGAMATED (Manhattan)—Crosscut on 700 level has entered fault zone adjoining ore zone opened on 350 and 600 levels. Heavy flow of water struck in crosscut but pumps handling it without difficulty.

WHITE CAPS (Manhattan)—Preparations made to sink shaft another 125 ft.

WILLIAM PATRICK (Manhattan) — Ground developed warrants installation of mill. Huntington mill has been purchased.

LABOR SITUATION IN TONOPAH is serious, labor being both scarce and inefficient. The Tonopah Belmont company, largest employers of labor in the district, has adopted a contract system, paying by footage or tonnage, which makes it possible for employees to earn more than the regular day's pay of district.

GREAT WESTERN (Tonopah)—Oreshoot recently opened on 1150 level 1500 ft. beyond point where ore was known to occur in adjoining West Tonopah ground. Further development work to be done on 1050 and 1100 levels, as soon as present excessive water flow stops.

MONTANA TONOPAH (Tonopah)—Operated entirely on leasing system for past four years, will again be operated by company. One of first properties in Tonopah district to open high-price ore. Charles Knox is president.

TONOPAH EXTENSION (Tonopah)—Extensive development work in Merger and Victory veins continue to open milling-grade ore. Over 300 tons daily being milled. Large flow of water struck in sinking Victory shaft 10 ft. below 1750 level, retarding progress of work. New pump to be installed at 1680 level.

WEST END CONSOLIDATED (Tonopah)—Connection made on 800 level between West End shaft and Ohio shaft workings. Regular development has blocked out large tonnage of ore in Ohio ground, which, until connection was made with West End shaft, could not be handled, as Ohio shaft is old and not properly equipped. Mill tonnage from mine to be increased.

OKLAHOMA

Joplin District

SKELTON (Douthat)—Two of six mills idle have resumed operations.

STERLING (Douthat) — Commenced operations after idleness of six months.

CONSTITUTIONAL (Miami)—Plan to start Midas plant in North Century after sinking shaft to 225 level.

MAGNETIC (Miami) — Has purchased lease of Johnson Mining and Development Co. Drilling property; has cleaned out old shaft and plans to build mill soon.

BLACKHAWK (Picher)—Building 350-ton mill.

OZARK LEAD AND ZINC (Picher)—Has suspended mining on account of water. Pumps being installed.

WALKER (Picher)—Treating ore from six shafts—four on its own lease and two on adjoining tract.

RED ROSE (Quapaw)—Sinking shaft to deeper level and cut ore at 182 feet.

OREGON

Coos County

COAL & METAL TRUSTEES (Marshfield)—Have taken over Granite and Rusty Butte groups of copper mines; also Monumental and Salmon groups of gold mines, which they purpose developing. Properties are all old producers.

INMAN (Marshfield)—Completed tunnel to divert Saxes river.

SOUTH DAKOTA

Lawrence County

SEIM (Deadwood)—Loading pyrites for shipment to eastern market.

CUSTER PEAKE (Roubaix) — Copper ore mined from Jungle mine for shipment to smeltery. Boiler and hoist being installed.

Pennington County

AMERICAN TIN AND TUNGSTEN (Hill City)—Cowboy mine being unwatered. Mohawk and Anna also to be worked. Additions under way at concentrator. Motor truck to be used to transport ore to railroad.

BLUE LEAD (Hill City)—New boiler and compressor to be installed.

LAST CHANCE (Keystone) — Making regular shipments of mica under lease to Producers' Mica Co., of Chicago.

LITHIA MINES (Keystone)—All lithia properties making regular shipments. Shortage of labor prevents larger output.

UTAH

Beaver County

UTAH SULPHUR CORPORATION (Milford)—Work begun in old sulphur mine at Sulphurdale; material and supplies being hauled. New company prospecting area of about 70 acres with core drills. New buildings being put up at Sulphurdale, now to be known as Morrissy, named after M. P. Morrissy, president. Expect to begin shipments soon.

Juab County

GODIVA (Eureka)—Lessees continuing shipments. Has cut new ore on 900 level and below 1200 level.

TINTIC MILLING (Silver City)—Newly leased Dragon Consolidated ground expected to furnish tonnage to keep mill supplied.

SCOTIA (Tintic)—Fourth car silver-lead ore shipped recently. Workings to be deepened.

Piute County

BRADBURN (Marysvale) — To build nine buildings and 150-ton bin to hold potash ore. Property adjoins Mineral Products and Florence Mining and Milling Co's. claims.

Salt Lake County

MICHIGAN-UTAH (Alta) — Shipping three cars daily of lead-silver and copper ore.

HIDDEN TREASURE (Bingham)—Leased to George Yeadon. High-grade lead-silver ore has been cut.

OHIO COPPER (Bingham)—Fire starting at trestle of Mascotte tunnel at Lark destroyed trestle and damaged mill. Expect to have three units of flotation section operating in a month.

MIDVALE MINERALS (Midvale)—Treating old U. S. mill dumps near smeltery.

Summit County

ONTARIO (Park City)—Recently opened oreshoot on 1600 and 1700 levels which is furnishing large part of output. Water being taken care of by pumping equipment on 1700 level.

CANADA

British Columbia

VELVET (Rossland)—Under investigation by Granby Consolidated. Main shaft down 500 ft. and six levels opened up. Mine closed down for some time.

Ontario

ANKERITE (Porcupine) — Extensive diamond-drilling campaign to be carried on to determine extent of two large parallel orebodies at depth.

DAVIDSON (Porcupine)—New section of property being developed. Second shaft being sunk to 750 level from a point 300 ft. north of No. 1 shaft. Diamond drilling has shown orebody at depth of 544 ft.

DOME (Porcupine)—Development being continued at 1250 level. A raise from this level is underway.

COBALT DISTRICT SHIPMENTS for the week ended Aug. 16 were: Coniagas, 170,370 lb.; Buffalo, 87,884; McKinley-Darragh, 83,592; La Rose, 65,943; Penn-Canadian, 64,688; O'Brien, 64,100; National, 60,655 lb. Total, 597,242 pounds.

GENESEE (Cobalt) — Development at 500 level has been retarded by water difficulties. Extra pumping equipment is being installed.

GREEN MEEHAN (Cobalt)—Edward-Wright Co. operators have decided to continue work at greater depth.

LAKE SHORE (Kirkland Lake)—During July estimated output was $39,000, recovered from 1580 tons of ore, averaging $24.68 per ton. Mill ran 84% of possible running time.

COLTER (Boston Creek)—Property lying east of the Miller Independence has been purchased by Toronto interests identified with the Bourkes mine.

HILL (Painkiller Lake)—Mill building being enlarged and alterations made. Underground operations temporarily suspended.

MEXICO

Baja California

COMPAGNIE DU BOLEO (Canta Rosalia)—Copper production during July was 1,697,360 lb. Copper ore averaged 3.29% copper.

The Market Report

SILVER AND STERLING EXCHANGE

Aug.	Sterling Exchange	Silver New York, Cents	Silver London, Pence	Aug.	Sterling Exchange	Silver New York, Cents	Silver London, Pence
22	4.7550	101⅛	49½	26	4.7550	101⅛	49½
23	4.7550	101⅛	49½	27	4.7550	101⅛	49½
24	4.7550	101⅛	49½	28	4.7550	101⅛	49½

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of bar silver, 999 fine. London quotations are in pence per troy ounce of sterling silver, 925 fine.

DAILY PRICES OF METALS IN NEW YORK

Aug.	Copper Electrolytic	Tin Spot.	Lead N. Y.	Lead St. L.	Zinc St. L.
22	*26	†	8.05	7.75	@9 9¼
23	*26	†	8.05	7.75	@9¼
24	*26	†	8.05	7.75	9¼ 9¼
26	*26	†	8.05	7.75	@9¼ 9¼
27	*26	†	8.05	7.75	@9¼ 9.10
28	*26	†	8.05	7.75	@9.20

*Price fixed by agreement between American copper producers and the U. S. Government, according to official statement for publication on Friday, September 21, 1917, and July 2, 1918.

†No market.

The above quotations (except as to copper, the price for which has been fixed by agreement between American copper producers and the U. S. Government, wherein there is no free market) are our appraisal of the average of the major markets based generally on sales as made and reported by producers and agencies, and represent to the best of our judgment the prevailing values of the metals for the deliveries constituting the major markets, reduced to basis of New York, cash, except where St. Louis is the normal basing point.

The quotations for electrolytic copper are for cakes, ingots and wirebars.

We quote electrolytic cathodes at 0.05 to 0.10c. below the price of wirebars, cakes and ingots.

Quotations for spelter are for ordinary Prime Western brands. We quote New York price at 35c. per 100 lb. above St. Louis.

LONDON

Aug.	Copper Standard Spot	Copper Standard 3 M.	Copper Electrolytic	Tin Spot	Tin 3 M.	Lead Spot	Lead 3 M.	Zinc Spot
22	122	122	137	373½	373½	29½	28½	54
23	122	122	137	371½	371½	29½	28½	54
24	...	...	...	...	...	...	...	...
26	122	122	137	367½	367½	29½	28½	54
27	122	122	137	367½	367½	29½	28½	54
28	122	122	137	363½	363½	29½	28½	54

The above table gives the closing quotations on London Metal Exchange. All prices are in pounds sterling per ton of 2240 lb. For convenience in comparison of London prices, in pounds sterling per 2240 lb., with American prices in cents per pound the following approximate ratios are given, reckoning exchange at $4.7515: £29½ = 6.2576c.; £54 = 11.4545c.; £110 = 23.3333c.; £125 = 26.5151c.; £260 = 55.1513c.; £280 = 59.3937c.; £300 = 63.6362c. Variations, £1 = 0.2121205c.

Metal Markets

NEW YORK, Aug. 28, 1918

There were no new features of special interest in the metal markets this week.

Copper—The situation is apparently becoming a little easier, although producers are still much behind in their commitments. There is general uneasiness at the smelteries and refineries respecting the forthcoming draft.

We fell into an error in our report last week respecting the relations between the American Metal Co. and the Granby, owing to a misunderstanding on our part. The matter of selling contract between these companies has not come up for consideration.

Copper Sheets—The base price of copper sheets is 34½c. per lb. Copper wire is quoted at 29 to 30c. per lb. f.o.b. mill, carload lots, subject to any change in the price of copper.

Tin—The situation is still easier, owing to the large arrivals in this country, which during August will probably exceed 6000 tons. At the close we quote Straits at 90c., Banka at 86c., and Chinese at 83@84c.

Singapore quoted £373½, c.i.f., London, on Aug. 22; £371½ on Aug. 23; £367½ on Aug. 26; £365½ on Aug. 27; and £363½ on Aug. 28.

Lead—There is no change in the situation. September lead is no longer available except through the Lead Producers' Committee. Vigorous efforts toward a further curtailment of consumption are being made.

Zinc—The little boom that was in full swing last week continued until 9½c. was touched, with diminishing sales on the way up. The top notch was reached on Saturday, following which the market became dull and easier.

The continuance of the price of 12c. for Grade A spelter was not a bull argument on common. This was equivalent to imposing a maximum price for common as well as for Grade A; for with the contraction in the margin between these grades redistillation will necessarily be discontinued and more common spelter will become available, which will tend to cause the price for common spelter to fall off to the point of equilibrium. The only condition under which this factor would not operate is such a demand for common spelter as would elevate the price for it, regardless of the price for high grade. No such demand seems now to be in sight.

The President has approved an agreement made between the producers of sheet and plate zinc and the price-fixing committee of the War Industries Board, (after investigations by this committee in conjunction with the Federal Trade Commission as to the cost of production) that the maximum base price of 14c. per lb. f.o.b. plant for plate zinc, and 15c. per lb. f.o.b. plant for sheet zinc, shall be continued on deliveries from Sept. 1, 1918, to Jan. 1, 1919, subject to the usual trade discounts and extras or differentials that were in effect Feb. 13, 1918. These discounts and extras shall be effective on all contracts executed between Feb. 13, 1918, and Jan. 1, 1919. Sheet zinc shall be considered as including all gages of ¼ in. thickness and less and plate zinc as including all gages thicker.

The announcement with regard to Grade A zinc is as follows: "The President has approved an agreement, made between the producers of Grade A zinc and the price-fixing committee of the War Industries Board (after investigations by this committee in conjunction with the Federal Trade Commission as to the cost of production) that the maximum price on Grade A zinc of 12c. per lb. f.o.b. East St. Louis shall be continued on deliveries between Sept. 1, 1918, and Jan. 1, 1919. The price at point of delivery is to be the East St. Louis price plus the freight from East St. Louis to point of delivery."

Zinc Sheets—Unchanged at $15 per 100 lb., less usual trade discounts and extras as per list of Feb. 4.

Other Metals

Aluminum—Unchanged. In announcing the continuation of the maximum price fixed for aluminum, the War Industries Board issued the formal statement which follows in part:

"The President has approved an agreement made between the producers of aluminum and the price-fixing committee of the War Industries Board (after investigations by this committee in conjunction with the Federal Trade Commission as to the cost of production) that the maximum base price for aluminum of 33c. per lb. f.o.b. U. S. producing plants, for 50 tons and over, of ingot of 98% to 99%, be continued until Mar. 1, 1919. Differentials for sheet, rod and wire and differentials for quantity, for grade and for alloys will remain those approved by the price-fixing committee as effective from June 1, 1918. Copies of the price list including differentials may be obtained upon application to the non-ferrous metals section of the War Industries Board.

"These prices will be effective on deliveries made during the period from Sept. 1, 1918, to Mar. 1, 1919, on contracts made during said period; and, furthermore, the new prices will be effective on deliveries made during said period on existing contracts which specify that the price shall be that in force at the time of delivery. Deliveries made during the period of Sept. 1, 1918, to Mar. 1, 1919, on other contracts shall be at the price stated in such contracts, except that on existing direct and indirect Government contracts containing a provision that refund is to be made of the difference between the price stated in the contract and the 'Government fixed price, if, as and when made,' such difference shall be refunded on deliveries made during the period from Sept. 1, 1918 to Mar. 1, 1919, on presentation of proper proof that the purchasing government gets the benefits of the refund. The conditions are the same as before."

Antimony—This market touched 14½c. during the week, at which point the demand lessened and the market became dull and easier. At the close we quote spot at 14¼@14½c. We quote futures at 13½c., c.i.f., in bond, for September shipments, and 13½c. for September-October.

Bismuth—Metal of the highest purity for pharmaceutical use is quoted at $3.50 per lb. for wholesale lots—500 lb. and over.

Cadmium—This metal is quoted at $1.50 @ $1.75 per pound.

Nickel—Market quotation: Ingot 40c.; shot 43c.; electrolytic 45c. per lb.

Quicksilver—This market became a little stronger, and we quote $125@$127.50. San Francisco reports by telegraph, $120, steady.

Silver and Platinum

Silver—Quotations have remained unchanged the last week in London and New York. Silver is in demand at the maximum price fixed by the Treasury of $1.01⅛ per fine oz. on orders from the British government for shipment to London and India, and the market is likely to rule steady and unchanged for some time.

Mexican dollars at New York: Aug. 22, 78; Aug. 23, 78; Aug. 24, 78; Aug. 26, 78; Aug. 27, 78; Aug. 28, 78.

Platinum, Palladium and Iridium—Prices fixed at $105, $135 and $175, respectively.

Zinc and Lead Ore Markets

Joplin, Mo., Aug. 24—Blende, per ton, high, $77.45; basis 60% zinc., premium, $75; Class B, $65@60; Prime Western, $55; calamine, , basis 40% zinc, $37.50@32. Average selling prices: Blende, $56.60; calamine, $36.71; all zinc ores, $55.93.

Lead, high, $103.20; basis 80% lead, $100; average selling price, all grades of lead, $100.32 per ton.

Shipments the week: Blende, 7125; calamine, 247; lead, 1077 tons. Value, all ores the week, $523,180.

With the upward shift of spelter the first of the week, sellers thought of holding for $60 basis. As spelter lowered and only two buyers were in the market for a normal tonnage, sales were made on $55 basis, but nothing was reported lower except slimes and flotation concentrates, which sold at $50 and $45 basis. Shipments were lowered over one-third from lack of cars, buyers having a large purchased tonnage in bins.

Platteville, Wis., Aug. 24—Blende, basis, 60% zinc, highest price reported, $72; base price for premium grade, $75; base price for high-lead blende, $47.50 per ton. Lead

ore, basis 80% lead, $95 per ton. Shipments reported for the week were 2426 tons blende, 90 tons galena and 615 tons sulphur ore. For the year to date the totals are 84,707 tons blende, 4899 tons galena and 32,432 tons of sulphur ore. During the week 2557 tons blende was shipped to separating plants.

Other Ores

Chrome Ore—Dull and easy, with sellers over. Ore of 40% grade is quoted nominally at $1.40 per unit.

Manganese—Unchanged.

Molybdenum Ore—A little more inquiry is reported, with sales at $1.

Tungsten—Spot tungsten ores have been sold to a considerable extent during the week. There is little scheelite of the highest grade obtainable. Buyers who are making inquiries for monthly supplies to cover the rest of this year have had little encouragement in offerings of high-grade scheelite, which sold for $25.50 per unit. High-grade wolframite has sold for from $24.50 to $25.50 per unit. Lower grade ores have sold at prices ranging from $20 to $24, according to the amount and kind of impurity.

Pyrites—Spanish lump is quotable to those who possess a license from the Government at 17c. per unit on the basis of 9s. ocean freight, buyer to pay war risk, less 2% and excess freight; but no sulphur imports are being received. Domestic pyrites is selling at a price of 25c. per unit, f.o.b. mine, according to delivery basis. Some mines in the South are reporting prices as 34c. per unit for lump and 32c. per unit for fines f.o.b. mines. Unchanged.

Iron Trade Review

PITTSBURGH—Aug. 27

In keeping with the trend of the last few months, the War Industries Board's estimate of the steel requirements has increased further, and as high as 25,000,000 net tons for the current half year has been mentioned, although a conservative estimate for that period's production is not over 18,000,000 net tons.

Pig Iron—The steel mills continue short of pig iron, and allocations are frequently required to keep them going. Practically no pig iron is being delivered except for purposes far up in the preference list. Ordinary market transactions are absent. After the recent activity in contracting for the first half of 1919, such business is practically ended, and the total volume was not large. The market remains quotable at the set limits: Bessemer, $35.20; basic, $32; foundry, $33; malleable, $33.50; forge, $32, f.o.b. furnace, freight to Pittsburgh from Valleys being $1.40 and from six detached furnaces somewhat less.

Steel—There are occasional offerings of small lots of odds and ends of discard steel, but discard steel of favorite analysis and size is generally absorbed in war work. Ordinary soft steel offerings are practically non-existent. The market remains quotable at the set limits: Billets, $47.50; sheet bars and small billets, $51; slabs, $50; rods, $57.

Scrap—The scrap committee of the Institute and the American Board of Scrap Iron Dealers have both issued sharp circular letters regarding the rather widespread abuse of the regulations as to selling heavy melting steel limited to $29, as the so-called "unguaranteed low-phosphorus scrap," at $34. The Institute committee calls upon steel works to stop making such purchases, and the scrap dealers' association calls upon dealers to stop making such sales. Each circular promises "drastic action" if the practices are not stopped.

Ferroalloys—There is only a moderate amount of ferromanganese business being done as a result of the recommendation of the Institute that consumers place contracts for the first half of 1919. Some are covered, though in instances large consumers have hardly started to buy. There seems to be little apprehension that the market will advance. The market has been steady for some time at $250, delivered, for 70% alloy, with $4 a unit for higher manganese content. Though the price was not fixed in the same manner as pig iron and steel prices were fixed, it is regarded as an authorized price. Spiegeleisen continues at $75, furnace, for 16 per cent.

Coke—The byproduct ovens are having more trouble getting full supplies of coke, and there has been practically no stocking against winter difficulties. The Carnegie Steel Co. now has about 350 ovens in operation of the 640 byproduct ovens at Clairton that have been under construction for more than two years, but the output is not yet up to rated capacity. The whole original plant is expected to show full production by the end of the year, with 768 additional ovens due next year. Connellsville coke production has suffered a little on account of the coal drain for byproduct ovens, but the total coke output from Connellsville coal, by beehive and byproduct ovens combined, has increased in the last three or four months.

MONTHLY AVERAGE PRICES OF METALS

Silver	New York			London		
	1916	1917	1918	1916	1917	1918
Jan.	56.775	75.630	88.702	26.960	36.682	44.356
Feb.	56.755	77.585	85.716	26.975	37.742	42.792
Mar.	57.935	73.861	88.082	27.597	36.410	43.620
April	64.415	73.875	95.346	30.662	36.963	47.215
May	74.269	74.745	99.505	35.477	37.940	48.980
June	65.024	76.971	99.500	31.060	39.065	48.875
July	62.940	79.010	99.625	30.000	40.110	48.813
Aug.	66.083	85.407		31.498	43.418	
Sept.	68.515	100.740		32.584	50.920	
Oct.	67.855	87.332		32.361	44.324	
Nov.	71.604	85.891		34.192	43.584	
Dec.	75.765	85.960		36.410	43.052	
Year	65.661	81.417		31.315	40.851	

New York quotations cents per ounce troy, fine silver; London, pence per ounce, sterling silver, 0.925 fine.

Copper	New York		London			
	Electrolytic		Standard		Electrolytic	
	1917	1918	1917	1918	1917	1918
Jan.	28.673	23.500	131.921	110.000	142.895	125.000
Feb.	31.750	23.500	137.895	110.000	148.100	125.000
Mar.	31.481	23.500	136.750	110.000	151.000	125.000
April	27.935	23.500	133.842	110.000	147.158	125.000
May	28.788	23.500	130.000	110.000	142.000	125.000
June	29.962	23.500	130.000	110.000	142.000	125.000
July	26.620	25.904	128.409	119.913	140.409	134.913
Aug.	25.380		122.391		137.000	
Sept.	25.073		117.500		135.250	
Oct.	23.500		110.000		125.000	
Nov.	23.500		110.000		125.000	
Dec.	23.500		110.000		125.000	
Year	27.180		124.892		138.401	

Tin	New York		London	
	1917	1918	1917	1918
January	44.175	85.500	185.813	293.227
February	51.420	92.000	198.974	311.525
March	54.388	(a)	207.443	318.875
April	55.910	(a)	220.171	329.905
May	63.173	(a)	245.114	364.217
June	62.053	(a)	242.083	331.925
July	62.570	(a)	242.181	360.347
August	62.681		243.978	
September	61.542		244.038	
October	61.851		247.467	
November	74.740		274.943	
December	87.120		298.556	
Av. year	61.802		237.563	

(a) No average computed.

Lead	New York		St. Louis		London	
	1917	1918	1917	1918	1917	1918
January	7.626	6.782	7.530	6.684	30.500	29.50
February	8.636	6.973	8.595	6.899	30.500	29.50
March	9.199	7.201	9.120	7.091	30.500	29.50
April	9.288	6.772	9.158	6.701	30.500	29.50
May	10.207	6.818	10.202	6.704	30.500	29.50
June	11.171	7.611	11.123	7.511	30.500	29.50
July	10.710	8.033	10.644	7.750	30.500	29.50
August	10.594		10.518		30.500	
September	8.680		8.611		30.500	
October	6.710		6.650		30.500	
November	6.249		6.187		30.500	
December	6.375		6.312		30.500	
Year	8.787		8.721		30.500	

Spelter	New York		St. Louis		London	
	1917	1918	1917	1918	1917	1918
January	9.619	7.836	9.449	7.661	48.329	54.000
February	10.045	7.814	9.875	7.639	47.000	54.000
March	10.300	7.461	10.130	7.286	47.000	54.000
April	9.459	6.890	9.289	6.715	54.632	54.000
May	9.362	7.314	9.192	7.114	54.000	54.000
June	9.371	8.021	9.201	7.791	54.000	54.000
July	8.643	8.373	8.473	8.338	54.000	54.000
August	8.360		8.190		54.000	
September	8.136		7.966		54.000	
October	7.983		7.813		54.000	
November	7.847		7.672		54.000	
December	7.685		7.510		54.000	
Year	8.901		8.813		52.413	

New York and St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Pig Iron, Pgh.	Bessemer‡		Basic‡		No. 2 Foundry	
	1917	1918	1917	1918	1917	1918
January	$35.95	$37.25	$30.95	$33.95	$30.95	$33.95
February	36.37	37.25	30.95	33.95	30.95	33.95
March	37.37	37.25	33.49	33.95	35.91	33.95
April	42.23	36.15	38.90	32.95	40.06	33.95
May	46.94	36.20	42.84	33.00	43.60	34.00
June	54.22	36.36	50.05	33.16	50.14	34.16
July	57.45	36.60	53.80	33.40	53.95	34.40
August	54.17		50.37		53.95	
September	46.40		42.24		48.58	
October	37.25		33.95		33.95	
November	37.25		33.95		33.95	
December	37.25		33.95		33.95	
Year	$43.57		$39.62		$40.83	

‡ As reported by W. P. Snyder & Co.

STOCK QUOTATIONS

N. Y. EXCH.†	Aug. 27
Alaska Gold M.	3⅛
Alaska Juneau	2
Am.Sm.& Ref.,com.	77¼
Am. Sm. & Ref., pf.	105
Am. Sm. Sec., pf., A	90½
Am. Zinc	17⅛
Am. Zinc, pf.	49½
Anaconda	67⅛
Batopilas Min	1⅛
Bethlehem Steel	85
Butte & Superior	26⅛
Butte Cop. & Zinc	‡11⅛
Cerro de Pasco	33⅛
Chile Cop.	16⅛
Chino	39⅛
Colo. Fuel & Iron	46⅛
Crucible Steel	69
Crucible Steel, pf.	90⅛
Dome Mines	8⅛
Federal M. & S.	15⅛
Federal M. & S., pf.	42
Great Nor., ore ctf.	32⅛
Greene Cananea	45
Gulf States Steel	80⅛
Homestake	75
Inspiration Con.	53
InternationalNickel	29⅛
Kennecott	33⅛
Lackawanna Steel	84⅛
Mexican Petrol	100⅛
Miami Copper	27⅛
Nat'l Lead, com.	58⅛
National Lead, pf.	101⅛
Nev. Consol.	20⅛
Ontario Min	9⅛
Ray Con	24
Republic I.&S.,com	93⅛
Republic I. & S., pf.	101
Sloss-Sheffield	61⅛
Tennessee C. & C.	18⅛
U. S. Steel, com.	115⅛
U. S. Steel, pf.	110⅛
Utah Copper	82⅛
Va. Iron C. & C.	73

BOSTON CURB*	Aug. 27
Alaska Mines Corp.	.12
Boston Ely	.60
Boston & Mont.	.48
Butte & Lon'n Dev.	.15
Calaveras	1
Chief Con.	2⅛
Contact	.15
Corbin	.10
Cortez	.08
Crown Reserve	.15
Crystal Cop.	.44
Eagle & Blue Bell	2⅛
Houghton Copper	.75
Intermountain	‡.05
Iron Cap	19⅛
Mexican Metals	.40
Mines of America	1
Mojave Tungsten	.09
Nat. Zinc & Lead	.16
Nevada-Douglas	.45
New Baltic	.80
New Cornelia	17⅛
Oneco	.20
Pacific Mines	‡.35
Rex Cons.	.07
Yukon Gold	.90

SAN FRAN.*	Aug. 20
Alta	.03
Andes	.05
Best & Belcher	.02
Caledonia	.04
Challenge Con.	.03
Confidence	.06
Con. Virginia	.22
Gould & Curry	.01
Hale & Norcross	.02
Jacket-Cr. Pt.	.07
Mexican	.17
Occidental	‡.51
Ophir	.05
Overman	.02
Savage	.03
Sierra Nevada	.03
Union Con.	.40
Utah Con.	.01
Belmont	2.50
Jim Butler	.55
MacNamara	.31
Midway	.04
Mont.-Tonopah	.09
North Star	.06
Rescue Eula	.12
West End Con.	1.05
Atlanta	.03
Booth	.04
Comb. Frac.	‡.02
Florence	.11
Jumbo Extension	.10
Kewanaa	.03
Nevada Hills	.03
Nevada Packard	.27
Round Mountain	.18
Silver Pick	.05
White Caps	.24
Big Jim	‡.75
United Eastern	3.25

COLO. SPRINGS*	Aug. 20
Cresson Con.	4.81⅛
Doctor Jack Pot	.03⅛
Elkton Con.	.04⅛
El Paso	.10
Gold Sovereign	‡.02
Golden Cycle	1.69⅛
Granite	.17
Isabella	.04⅛
Mary McKinney	.07⅛
Portland	.80
United Gold M.	.13
Vindicator	.40

BOSTON EXCH.*	Aug. 27
Adventure	‡.60
Ahmeek	‡75⅛
Algomah	‡.15
Allouez	‡49
Ariz. Com., ctfs.	16
Arnold	‡.20
Bingham Mines	‡9⅛
Bonanza	‡.16
Butte-Balaklava	‡.25
Calumet & Ariz.	68⅛
Calumet & Hecla	464
Centennial	‡12
Copper Range	47⅛
Daly West	‡2
Davis-Daly	15⅛
East Butte	10
Franklin	‡3⅛
Granby	‡79
Hancock	6
Hedley	‡12
Helvetia	‡.15
Indiana	.60
Isle Royale	27
Keweenaw	‡.87
Lake	15
La Salle	‡2⅛
Mason Valley	‡3⅛
Mass	‡4⅛
Mayflower	2⅛
Michigan	‡2⅛
Mohawk	56⅛
New Arcadian	‡1⅛
New Idria	‡13
North Butte	‡14⅛
North Lake	‡.60
Ojibway	‡.65
Old Dominion	39⅛
Osceola	‡50⅛
Quincy	‡69⅛
St. Mary's M. L.	50
Santa Fe	.60
Seneca	‡11
Shannon	‡3⅛
Shattuck-Ariz.	‡15⅛
So. Lake	1
So. Utah	‡.16
Superior	‡4⅛
Superior & Bost.	3⅛
Trinity	3
Tuolumne	1⅛
U. S. Smelting	42⅛
U. S. Smelt'g, pf.	43⅛
Utah Apex	‡1⅛
Utah Con.	10
Utah Metal	2
Victoria	‡2
Winona	‡1⅛
Wolverine	22⅛
Wyandot	‡.50

N. Y. CURB†	Aug. 27
Big Ledge	⅛
Butte & N. Y.	‡.75
Butte Detroit	‡.15
Caledonia	.43
Calumet & Jerome	1⅛
Can. Cop. Corpn.	2
Carlisle	‡2
Cashboy	.05
Con. Ariz. Sm.	1⅛
Con. Coppermines	‡5
Con. Nev.-Utah	⅛
Emma Con.	‡.10
First Nat. Cop.	1⅛
Goldfield Con.	.21
Goldfield Merger	‡.03
Greenmonster	⅛
Hecla Min.	4⅛
Howe Sound	‡4⅛
Jerome Verde	‡.50
Louisiana	⅛
Magma	29
Majestic	.17
Marsh	‡.04
McKinley-Dar-Sa.	.42
Milford	‡.75
Mother Lode	.35
Nixon Nevada	.40
Ohio Cop.	1
Rawley	‡2⅛
Ray Hercules	4⅛
Richmond	‡.56
Rochester Mines	.34
St. Joseph Lead	14
Standard S. L.	⅛
Stewart	.33
Success	‡.12
Tonopah	2⅛
Tonopah Ex.	1⅛
Tribullion	⅛
Troy Arizona	.12
United Cop.	⅛
United Verde Ext.	37⅛
United Zinc	1⅛
Utica Mines	‡.08

TORONTO*	Aug. 27
Adanac	‡.06
Bailey	.03
Beaver Con.	.20
Chambers Ferland	.12
Coniagas	2.50
Hargraves	.04
Kerr Lake	5.62⅛
La Rose	.21⅛
Min. Corp. of Can.	2.00
Nipissing	8.37⅛
Peterson Lake	.08
Temiskaming	.28
Wettlaufer-Lor.	‡.03
Davidson	‡.25
Dome Exten.	.12
Dome Lake	.10
Hollinger	4.50
McIntyre	1.25
Newray	‡.56⅛
Porcu. Crown	.10
Teck-Hughes	‡.14
Vipond	.10
West Dome	.05

* Bid prices. † Closing prices. ‡ Last Quotations.